THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 37 MAY, 1937 No. 5

OSTEOPOROSIS CIRCUMSCRIPTA OF THE SKULL AND PAGET'S DISEASE*

FIFTEEN NEW CASES AND A REVIEW OF THE LITERATURE

By HAIG H. KASABACH, M.D., *and* ALEXANDER B. GUTMAN, M.D.
NEW YORK CITY

IN THIS communication, 15 new cases of osteoporosis circumscripta of the skull are recorded, together with follow-up studies on 6 cases previously reported by Kasabach and Dyke,[11] and 1 case previously reported by Schüller.[24] An attempt has been made also to summarize the roentgenologic, clinical, pathologic and biochemical characteristics of this interesting affection, so far as the data in the literature and our own material permit. The evidence relating osteoporosis circumscripta of the skull to Paget's disease is treated in some detail.

The term "circumscribed osteoporosis" was introduced by Schüller[23] in 1926 to designate a striking alteration in the roentgenologic appearance of the skull observed by him in 2 cases. There was a marked decrease in density of the bone comprising most of the anterior half of the calvarium, the borders of the affected area being irregular but sharply demarcated from the contiguous normal bone. The decrease in density was shown not to be the result of a bone defect but was thought to be due to localized osteoporosis, of unknown etiology. Moore,[16] in an article on osteitis deformans in 1923, had described similar skull changes in 1 of his cases (Case III) and had noted expansion of the involved area two and a half years after the initial examination, but did not consider that the changes constituted a distinct entity. In 1927, Sosman[26] re-examined Schüller's second case and recorded the results of pathologic examination of bone obtained from the affected area by trephination. The section showed "simultaneous proliferation and degeneration of bone, with complete absence of haversian system similar to Paget's disease." Sosman suggested that osteoporosis circumscripta of the skull might be an atypical form of Paget's disease, possibly "the absorptive or destructive phase of Paget's disease, with the productive phase held in abeyance." In 1929, Schüller[24] published a more detailed account of the 2 cases previously described and added 3 new cases. He remarked that osteoporosis circumscripta might be "a bone disease similar to Paget's disease [as Sosman had suggested] or to osteomalacia, perhaps a mild form of these diseases."

In 1930, Weiss[30] reported 2 cases presenting typical Paget involvement of several parts of the skeleton but without "cotton-wool" changes in the skull which

* From the Departments of Radiology and Medicine, College of Physicians and Surgeons, Columbia University and the Presbyterian Hospital, New York. Read at the Thirty-seventh Annual Meeting, American Roentgen Ray Society, Cleveland, Ohio, Sept. 29–Oct. 2, 1936.

showed instead large, sharply circumscribed areas of decreased density, consistent with osteoporosis circumscripta. Shortly thereafter, Weiss[31] added a third case in which the frontal and anterior temporal regions of the skull exhibited the characteristics of osteoporosis circumscripta whereas the occipital region presented a typical "cotton-wool" appearance. The intervening parietal area showed a gradual transition from one type of bone change to the other. Weiss regarded these observations as strong evidence for the view that osteoporosis circumscripta is a manifestation of Paget's disease; a relatively rare anatomical variant of the disease and one which might persist independently for years. Meyer-Borstel[15] published 3 additional cases illustrating the coexistence of osteoporosis circumscripta of the skull with typical Paget lesions elsewhere. He was inclined to regard osteoporosis circumscripta as more common than the few reported instances would indicate, constituting, in fact, an obligatory phase in the early development of Paget's disease, whether found in the skull or in other parts of the skeleton.

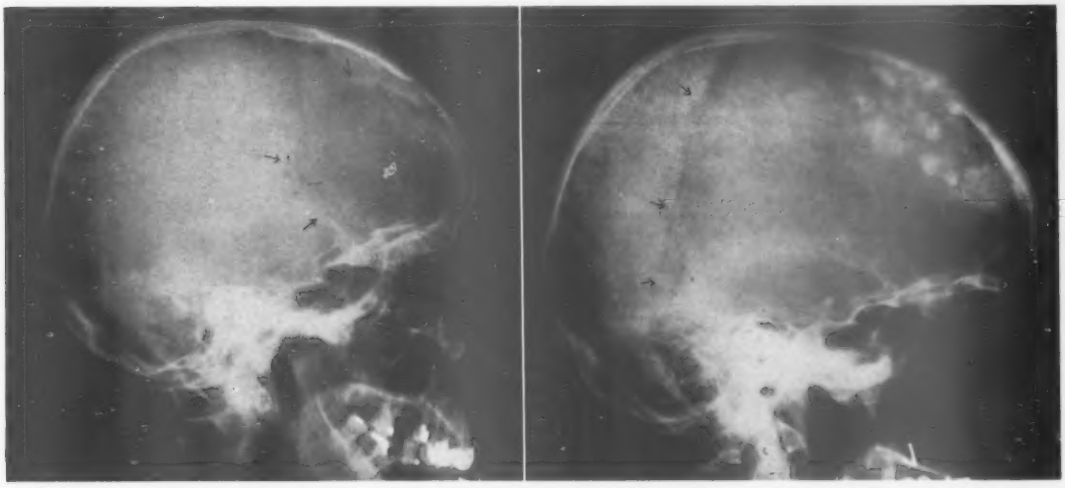
In 1932, Kasabach and Dyke[11] summarized their observations on 12 cases of osteoporosis circumscripta of the skull, of which 8 presented, in addition, typical sclerotic Paget lesions in the skull or elsewhere. In one instance, in which a roentgenogram of the skull had revealed the presence of osteoporosis circumscripta in 1922, it was found on re-examination in 1930 that the skull presented the full-blown picture of Paget's disease. In 3 other cases, followed for a number of years, sclerotic lesions in and around osteoporotic areas at the initial examination were observed to have increased in size and number. Kasabach and Dyke regarded osteoporosis circumscripta as "a form or precursor of Paget's disease where the osteolytic or rarefying phase predominates."

In addition to these larger series, isolated case reports have been published by Schellenberg,[20] Zaccaria,[34] Schueller,[25] Le Fort and Moreau,[13] Vilaça and De Almeida Toledo,[29] Bertel and Provvisionato,[1] Guillain, Ledoux-Lebard and Lereboullet,[5] and Erdheim.[4] In 4 of these cases,[1,4,13,29] osteoporosis circumscripta of the skull was associated with typical Paget's disease in the skull or elsewhere in the skeleton. Pines' case,[19] called a porotic form of Paget's disease of the calvarium, has not been included because of some doubt as to its identity with osteoporosis circumscripta.

REPORT OF CASES

CASE 1 (P. H. 63380). M. St., American housewife, was forty-three years old in 1925 when first admitted to the Presbyterian Hospital because of acute appendicitis. An incidental finding in the course of examination was a painless swelling and anterior bowing of the left tibia, first noted by her in 1918, with progressive bowing since then. Diagnosis: Paget's disease of the left tibia, no clinical evidence of bone involvement elsewhere. Roentgenograms (1925) confirmed the diagnosis of Paget's disease of the left tibia and disclosed typical sclerotic lesions in the pelvis, sacrum, distal third of the right femur, upper third of the right tibia, head of the right humerus and second metacarpal of the left hand. Her course since then has been practically asymptomatic except for increasing bowing of the left tibia with some attendant disturbance in gait. At no time have there been any signs or symptoms of the head referable to osteoporosis circumscripta.

In 1925, roentgenograms of the skull (Figs. 1*a* and 11, VI) showed a rounded area of osteoporosis circumscripta about 7 cm. in diameter in the right frontal region. This was not recognized at the time. No sclerotic lesions were present. In 1927, films of the skull showed that several sclerotic bone islands had developed within the area of osteoporosis. Re-examination of the skull in 1935 (Figs. 1*b* and 11, VI) revealed considerable expansion of the area of osteoporosis to include the frontal, temporal and greater part of the parietal regions, leaving the occipital bone intact. Numerous shadows of increased density, typical of Paget's disease, had developed within the osteoporotic frontal and parietal areas. Films of the left tibia and right femur showed further extension of the Paget's disease.



a *b*

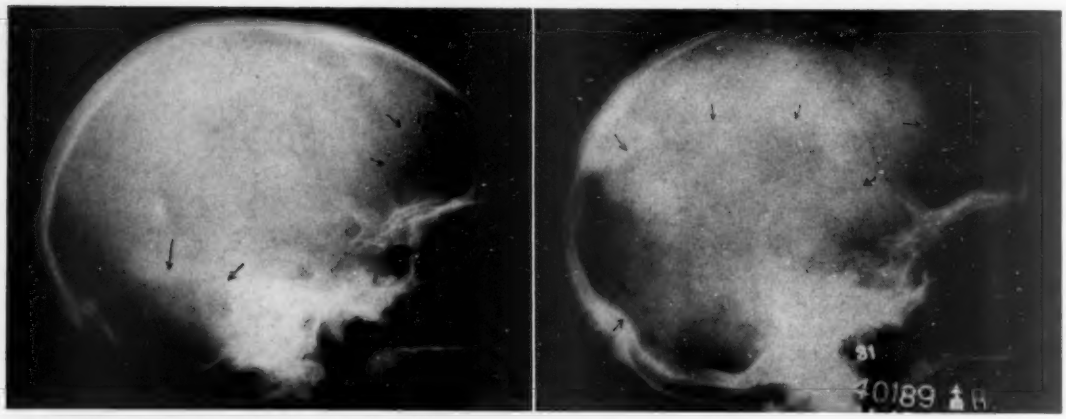
Fig. 1. Case I. *a*. Lateral view of the skull in 1925 showing an osteoporotic area in the frontal bone; *b*, same view, 1935. Note the expansion of the area of osteoporosis and the development of early Paget's disease in the frontal bone.

Case II (P. H. 276766). H. B., American female, now seventy-five years old, first came to the Presbyterian Hospital in 1926 because of bowing of the legs associated with pain and increasing difficulty in walking. The symptoms began about 1910 with acute pain in the right knee, and later in the left knee. Anterior bowing of the tibiae had been apparent since 1915 and the use of a cane had been necessary since 1925. Examination in 1926 revealed no deformities other than the marked bowing of the tibiae, suggestive of Paget's disease. This diagnosis was confirmed by roentgenograms which revealed, further, typical Paget involvement of the pelvis and upper third of the left femur. Hypertrophic osteoarthritis was also present. Her clinical status since then has changed but little; there is increasing bowing of the legs, difficulty in walking, and intermittent arthritic pain. At no time has she had any signs or symptoms referable to osteoporosis circumscripta or to Paget's disease of the skull.

Films of the skull in 1926 (Fig. 12, VIII) showed osteoporosis circumscripta involving the occipital, and posterior half of the parietal bones, extending anteriorly to the vertex and inferiorly to the foramen magnum. This was not recognized at the time. There was slight expansion of the parietal bone. No sclerotic areas were present. The choroid plexus in the posterior horn was partially calcified. Re-examination in 1935 (Fig. 12, VIII) showed numerous fine shadows of increased density now present in the parietal and adjacent occipital regions; osteoporosis was seen only in the superior part of the occipital bone. The tibiae showed increased expansion and bowing, with progression of the Paget involvement distally. The lower ends of both femora and both patellae were now involved.

Case III (P. H. 410269). M. Sh., American housewife, was sixty-one years old in 1920 when she first came to the Presbyterian Hospital because of nervousness and headache. The blood Wassermann reaction was found to be positive and she was given specific treatment. In 1927, she complained of pain in the legs and lower back. No bone deformities were demonstrable clinically. Roentgenograms of the skeleton revealed Paget's disease involving the pelvis, spine, both femora and the right scapula. Intermittent pain in the legs and back has persisted since then, but no bony deformities clinically demonstrable have developed. The Wassermann test has been negative since 1930. Her course in the past three years has been dominated by symptoms due to arteriosclerosis, arterial hypertension and myocardial failure. The only symptom referable to osteoporosis circumscripta of the skull or to Paget's disease is occasional vertigo, probably due to hypertension or arteriosclerosis.

Films of the skull in 1922, taken because of headache, showed no abnormalities. In 1927 (Fig. 2*a*), an area of osteoporosis circumscripta

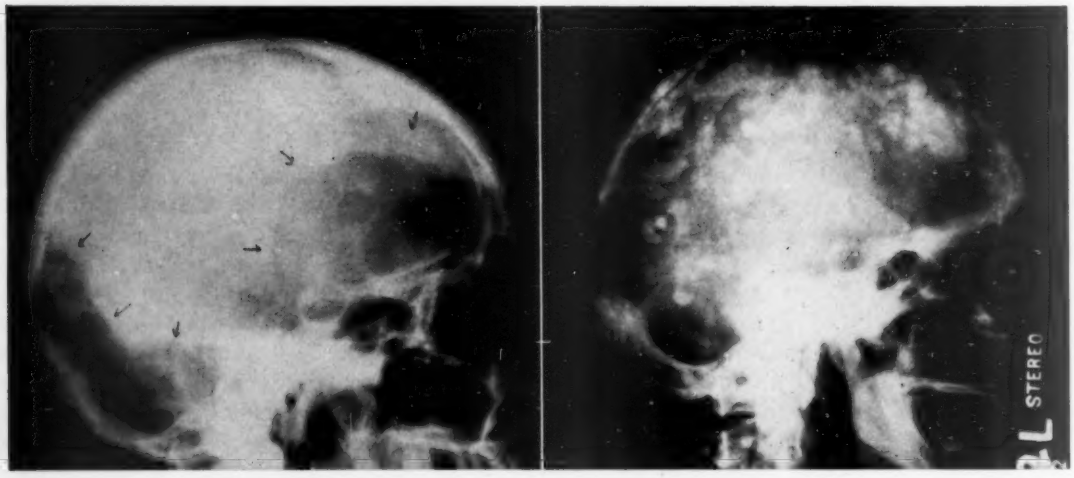


a *b*

Fig. 2. Case III. *a*. Lateral view of the skull in 1927 showing osteoporotic areas in the frontal and occipital regions; *b*, same view, 1935. Note the increase in the size of the osteoporotic area. The parietal region is now extensively involved. Early Paget changes have developed, particularly in the region of the vertex.

involving most of the occipital bone had appeared. The whole of the frontal bone was similarly affected. This was not recognized at the time. No sclerotic lesions were present. Re-examination of the skull in 1934 revealed expansion of the osteoporotic area, especially on the right side, to include the entire calvarium with the exception of the superior portion of the parietal bone on the right. Most of the parietal bone on the left side was still intact. Diffuse, rather granular sclerosis had developed within the osteoporotic bone, indicating Paget's disease. No further changes were apparent in films obtained in 1935 (Fig. 2*b*).

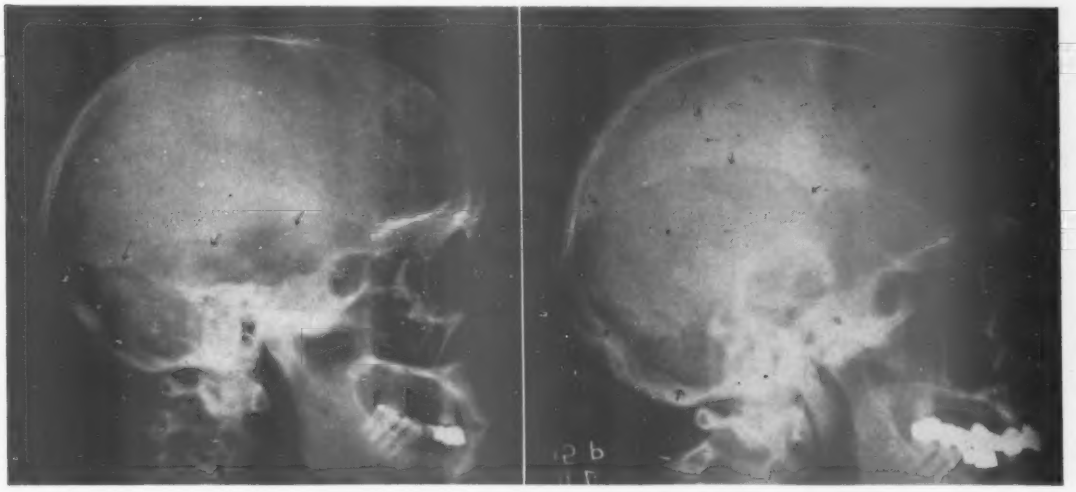
Case IV (N. I. 27325). L. N., American housewife, aged forty-two, came to the Neurological Institute in 1924 complaining of occipital headache for seven years, increasing in severity and duration for several months, at times accompanied by shooting pain from the occiput to the left ear; also occasional vomiting, premenstrual diarrhea, and gain in weight. Physical examination, apart from marked obesity, was negative. Because of the possibility of brain tumor, roentgenograms of the skull were obtained (1924) which revealed (Figs. 3*a* and 12, XI) osteoporosis circumscripta involving the frontal and temporal bones and extending



a *b*

Fig. 3. Case IV. *a*. Lateral view of the skull in 1924, showing osteoporosis circumscripta in the frontal, temporal and part of the parietal bones. A similar area is seen in the occipital bone; *b*, same view in 1932. The entire skull now presents typical Paget's disease. (Courtesy of Dr. C. G. Dyke.)

posteriorly to include the anterior and inferior portions of the parietal bone. On the right side of the frontal bone there were also two smaller circumscribed areas of osteoporosis about 1.5 cm. in diameter. A similar small area was observed in the squamous portion of the occipital bone. The fourth lumbar vertebra showed typical Paget's disease. Coarse trabeculations suggesting early Paget's disease were seen in the left iliac bone. Re-examination in 1932 (Figs. 3*b* and 12, XI) revealed a striking transformation in the appearance of the skull which now presented the typical picture of advanced Paget's disease. There were numerous "cotton-wool" shadows with marked thickening of the



a *b*

FIG. 4. Case V. *a*. Lateral view of the skull in 1932, showing circumscribed osteoporosis of the occipital bone; *b*, lateral view of the skull in 1935. With the exception of the parietal bone, practically the whole of the calvarium is osteoporotic.

tables. The base was sclerotic and showed "mushrooming" (convexobasie). The left clavicle, third and fourth lumbar vertebrae, and the left side of the pelvis together with the adjacent portion of the sacrum showed typical osteitis deformans.

CASE V (P. H. 465432). F. F., Italian male, aged thirty-six, formerly a professional boxer, applied to the Presbyterian Hospital in 1935 for alleviation of deafness. Neither his parents nor grandparents were known to have had any bony disorders. His father is said to have been luetic. His older brother had osteoporosis circumscripta of the skull and Paget's disease (see Case XXII)*. His two sisters, both dead (one at twenty-one, the other at twenty-four), were deaf but neither had obvious bone disease. One brother, now aged thirty, is said to have a bony deformity of the face.

In 1921, he noted impairment of hearing on the right side, later also on the left. In 1931, he fell and fractured his left humerus. Roentgenograms disclosed Paget's disease of the proximal third of the humerus, at the site of the fracture. In 1932, a film of the skull (Figs. 4*a* and 11, 1) revealed osteoporosis circumscripta of the occipital region extending from just above the torcular Herophili anteriorly to the mastoid region. The frontal bone was also involved, seen best in posteroanterior views. No sclerotic lesions were present. The right side of the pelvis, upper end of the right femur, first rib on the right side, upper third of both humeri, and the lower lumbar vertebrae exhibited the characteristic appearance of osteitis deformans.

In 1935, deafness was more marked and he complained of occasional attacks of vertigo. He had no headache. There were no bony deformities made out on clinical examination. Audiograms showed marked nerve deafness on both sides, particularly the right. Films of the skull in 1935 disclosed considerable extension of the osteoporotic area which now included the entire cranium except a patch of normal bone in the superior parietal region and a thin strip in the frontal region (Figs. 4*b* and 11, 1). There was some bundling of the trabeculae of the

* Subsequent investigation also showed osteoporosis circumscripta of the skull and Paget's disease in a cousin of this patient.

body of the sphenoid bone. No "cotton-wool" areas were seen. The involvement of the pelvis had become more extensive, encroaching upon the left ischium and pubis. The right os calcis also showed Paget's disease.

Case vi (P. H. 378041). W. F., Jewish male, aged forty-four, came to the Presbyterian Hospital in 1933 complaining of pain in the lower back radiating down the left leg, with limp. The onset was acute, three weeks before. Clinical examination suggested sciatic neuritis, no bone deformities were apparent. Films of the skeleton revealed Paget's disease of the pelvis, upper half of the right femur, lumbar and sacral spine. When last seen in 1935, no bone deformities were in evidence. He never exhibited any signs or symptoms referable to osteoporosis circumscripta of the skull.

Films of the skull in 1933 (Fig. 12, xvii) disclosed osteoporosis circumscripta involving the posterior half of the frontal bone on the left side, extending to the superior margin of the temporal and the anterior border of the parietal bone to the vertex. A small area of rarefaction was also present in the occipital bone. The diploic spaces of the frontal and occipital parts of the calvarium were widened and irregular. No sclerotic areas were present.

Case vii (P. H. 395124). D. S., an American male, aged thirty-five, came to the Presbyterian Hospital in 1933 for treatment of diabetes, hypertension, cardiac failure and impairment of vision. He had been known to be diabetic for fifteen years. Extensive calcification of his blood vessels had developed, with hypertension, retinal hemorrhages and renal damage. An incidental finding was lateral bowing of the tibiae, present as long as he could remember. There were no other bony deformities. Signs or symptoms referable to osteoporosis circumscripta of the skull or to Paget's disease were absent.

Films of the skeleton in 1933 (Fig. 12, xv) revealed osteoporosis circumscripta involving the right temporal region of the skull. Two small bony islands were seen in the frontoparietal region. There was some coarsening of the trabeculae of the mandible and at the base of the skull. The right ischium and the body of the right ilium showed Paget's disease. The tibiae exhibited anterior bowing and, on the left, slight cortical thickening not typical of osteitis deformans.

Case viii. E. S., an American female, aged thirty-seven, came to the Dental Clinic in 1935 because of loosening of the teeth of the lower jaw. Films of the teeth revealed expansion and coarse trabeculations of the mandible, suggesting Paget's disease or osteitis fibrosa. Films of the entire skeleton were then obtained, although no evidence of bone disease could be elicited on clinical examination. Typical advanced Paget's disease involving the pelvis, entire spine, and both scapulae was found. There was an old compression fracture of the ninth dorsal vertebra. The skull showed osteoporosis circumscripta of the frontal bone chiefly on the right side, extending posteriorly to the parietal and temporal areas. No sclerotic lesions were present (Fig. 12, xiii).

There were no clinical signs or symptoms referable to osteoporosis of the skull or to Paget's disease elsewhere. Later, however, she complained of pain in the lower back.

Case ix (P. H. 376539). M. V., a colored female, aged thirty-one, came to the Presbyterian Hospital in 1933 complaining of a constriction in the throat. An incidental finding in the course of examination (otherwise negative) was a moderate bony swelling of the maxilla on the left side. This had developed following the extraction of a tooth but was painless and had not increased in size recently. She returned in 1934 because of the maxillary tumor, now apparent externally as a swelling of the face, and headache. Films of the maxilla showed expansion, increased density and coarsened trabecular structure of the bone suggesting either osteitis fibrosa cystica or Paget's disease. A biopsy was obtained which was variously interpreted as osteoma, osteofibroma and Paget's disease but was finally called osteoma. Three weeks later, a large part of the maxilla was resected, without recurrence of the bony tumor to date, two years following operation. Her headaches have persisted however, becoming definitely migraine in character. Films of the sinuses were obtained (1934) which disclosed osteoporosis circumscripta of the frontal bone (Figs. 5*a*, 5*b*, and 12, xii). No sclerotic lesions were present in the calvarium or base of the skull. Re-examination in 1935 showed no change. The remainder of the skeleton presented no abnormalities.

Case x (P. H. 146866). F. S., an American male, aged fifty-seven, came to the Presby-

terian Hospital in 1926 complaining of drowsiness and increasing deafness. The only abnormality found on examination was expansion of the upper part of the left tibia. Roentgenograms disclosed advanced Paget's disease of the pelvis, upper thirds of the femora, both tibiae, upper humeri, scapulae, sacral and cervical spine. Skull (Fig. 12, XIV): Osteoporosis circumscripta (interpreted at the time as endothelioma or lues) involving the superior portion of the frontal and parietal bones on the left side. On the right, a small oval area was present at the junction of the frontal and parietal bones. Sclerotic lesions were absent.

femora exhibited the characteristic picture of advanced Paget's disease.

Case XII (P. H. 222590). A. C., an American male, aged fifty-eight, came to the Presbyterian Hospital in 1929 because of nocturnal epileptiform attacks for the preceding eighteen months. The attacks consisted of clonic convulsions, with biting of the tongue and frothing of the mouth, and loss of consciousness for periods up to one-half hour. They were followed by fatigue, headache and depression. Physical examination was essentially negative; the blood, spinal fluid and urine were negative. Films of the skull (1929) revealed osteoporosis

a *b*

Fig. 5. Case IX. *a*. Lateral view of the skull showing a sharply demarcated osteoporosis in the frontal bone; *b*, posteroanterior view. Note the sharply outlined osteoporosis beyond the shadow of the frontal sinus.

Case XI (P. H. 432570). J. S., a Jewish male, aged fifty-nine, came to the Presbyterian Hospital in 1934 complaining of deafness. He was found to have chronic middle ear disease and sinusitis involving both antra. No other abnormalities were demonstrable clinically. Film of the skull in 1935 (Fig. 12, XVI) revealed typical Paget's disease, most marked in the frontal and parietal regions, also involving the base of the skull. In addition, there was an oval area of osteoporosis circumscripta about 2×4 cm. in size in the occipital bone just above the torcular Herophili. A similar area was seen also in the temporal bone on the right side. The sella was considerably enlarged suggesting a pituitary tumor. The mandible showed coarse trabeculations and several areas of increased density. The pelvis, spine and both

circumscripta (not recognized at the time) involving the frontal, temporal and anterior part of the parietal bones. Numerous sclerotic bone islands typical of Paget's disease were scattered over the entire calvarium. The remainder of the skeleton was not examined.

Case XIII (P. H. 111663). A. N., a German housewife, aged forty-nine, was admitted to the Presbyterian Hospital in 1923 because of swelling and pain in the right leg, of six months' duration. Expansion and tenderness of the right tibia were found on clinical examination. Roentgenograms showed Paget's disease of the right tibia, right femur, left humerus, pelvis and lower dorsal spine. Osteoporosis circumscripta was present in the parietal and frontal regions of the skull (not recognized then).

CASE XIV. An American male, aged sixty-three, was found, upon routine films of the sinuses, to have osteoporosis circumscripta of the frontal region. There was no evidence of bone disease elsewhere in the skeleton. No symptoms referable to the osseous system were present.

CASE XV. An American male, aged sixty, complained of severe attacks of migraine on the right side. Roentgenographic examination of the skull (1934) showed osteoporosis circumscripta in the right temporal and parietal regions. The remainder of the skeleton was normal.

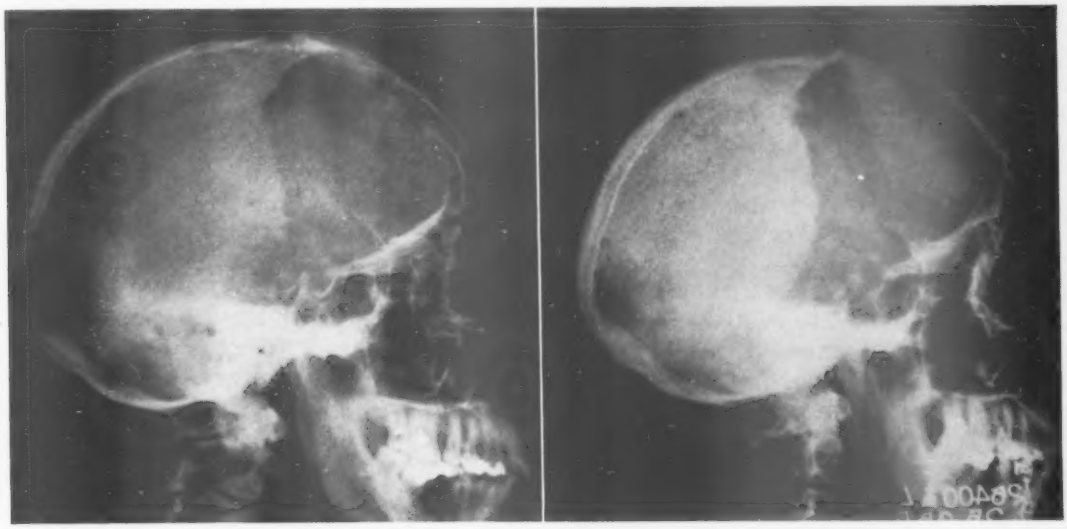
CASE XVI (Case III, Kasabach and Dyke, 1932; P. H. 465868). S. G., an American female, now aged forty-five, was admitted to the Neurological Institute in 1931 complaining of pain in the head and inability to concentrate. She attributed her symptoms to a severe blow in the head, sustained in 1924. No neurologic evidence of organic disease was found and she was discharged with the diagnosis of traumatic neurosis. Films of the skull in 1931 (Fig. 11, v) disclosed osteoporosis circumscripta of the occipital bone extending to the posterior part of the parietal bones. No sclerotic areas were present. Re-examination in 1935 (Fig. 11, v) disclosed definite expansion of the affected area of the skull, the process now involving the posterior portion of the parietal bones up to the vertex and the entire occipital bone to the foramen magnum. No "cotton-wool" shadows were present. No abnormalities were found in the remainder of the skeleton.

At her last visit to the Presbyterian Hospital in 1935, her chief complaint related to difficulty in vision. This was due to a marginal keratitis and to an ulcer of the cornea, of unknown etiology and refractory to all treatment. This had been present for a number of years. She complained also of headaches and occasional vertigo. The blood Wassermann test was negative.

CASE XVII (Case IV, Kasabach and Dyke, 1932; P. H. 428308). W. P., an American male, now aged thirty-nine, was admitted to the Neurological Institute in 1926, and again in 1931. Since 1922, he had suffered periodic attacks of confusion and disorientation, sometimes accompanied by vomiting and diplopia. Extensive investigation failed to reveal the cause and he was discharged unimproved with the diagnosis of paroxysmal disorder or epileptic equivalent. On readmission in 1934, it was found that his condition was due to hyperinsulinism and he was transferred to the Presbyterian Hospital where two adenomas of islet tissue were removed from his pancreas (ref. 32, Case IV). He has remained free of attacks since the operation. No symptoms referable to osteoporosis circumscripta of the skull have appeared.

Films of the skull (1931) revealed osteoporosis circumscripta involving the frontal bone, chiefly on the left side (Fig. 11, III). No sclerotic lesions were present. Re-examination in 1933 (Fig. 6*a*) showed extension of the osteoporotic area posteriorly to include the anterior part of the parietal and temporal bones on the left side. A rounded area of osteoporosis, about 3 cm. in diameter, had appeared in the occipital bone. The diploic space was slightly widened. No sclerotic areas had developed. Re-examination in 1935 (Figs. 6*b* and 11, III) showed further involvement of the parietal bones and the appearance of sclerotic lesions in the frontal bone. The remainder of the skeleton was normal.

CASE XVIII (Case V, Kasabach and Dyke 1932; P. H. 81877). I. W., an American widow, now aged sixty, came to the Presbyterian Hospital in 1929 complaining of pain and stiffness of the right knee and of anterior bowing of the right leg. The clinical diagnosis of Paget's disease was confirmed by roentgenograms (1929) which disclosed advanced Paget lesions in the lumbosacral spine, pelvis, upper femora, right tibia, head of the right humerus and the acromion of both scapulae. Skull (Figs. 7*a* and 11, VII): Osteoporosis circumscripta involving the frontal bone, together with several smaller areas in the occipital and parietal regions. A few bony islands were present in the osteoporotic frontal and anterior parietal regions. Re-examination of the skull in 1932 revealed extension of the frontal lesion posteriorly to include the anterior margin of the parietal bones. The focus in the occipital bone had expanded upward and anteriorly. The sclerotic bone areas had increased in number. Re-examination of the skull in 1933 (Fig. 11, VII) showed further extension of the frontal focus of osteoporosis which now included the greater part of the parietal and temporal regions. The occipital lesion extended inferiorly as far as the foramen magnum and anteriorly to the petrous portion

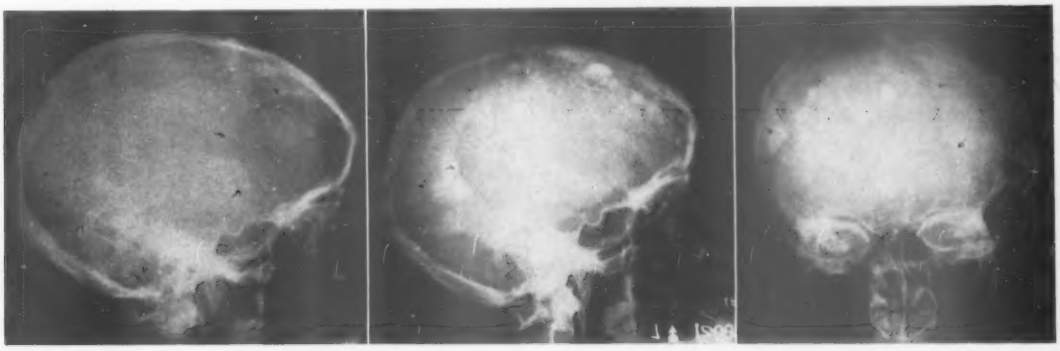


a *b*

Fig. 6. Case xvii. *a*. Lateral view of the skull in 1931. Note the sharply defined osteoporosis in the frontal bone; *b*, note the slight expansion of the circumscribed area in which shadows of increased density have appeared suggesting early Paget's disease (1935).

of the temporal bone. There remained only a thin band of normal bone on the left side in the mid-parietal region, 3 cm. in width in the region of the vertex and 8 cm. towards the base. The right side was similarly, but less extensively, involved. The number of "cotton-wool" shadows had increased somewhat. Re-examination of the skull in 1935 (Figs. 7*b*, 7*c* and 11, vii) disclosed further encroachment on the strip of normal bone which was now only 0.5 to 3 cm. in width. The process had advanced on the right side where a similar band of normal bone remained in the posterior parietal region, 4 to 6 cm. in width. The number of sclerotic areas had increased, particularly in the anterior half of the calvarium. Examination of the remainder of the skeleton showed further thickening and bowing of the right tibia.

Clinically, there was increased bowing of the right tibia with some interference with locomotion and pain in the lower back and right leg, most severe in the past year. The only symptom referable to osteoporosis circumscripta of the skull has been occasional mild headache, which might very well be ascribed to other causes.



a *b* *c*

Fig. 7. Case xviii. *a*. Lateral view of the skull (1929) showing circumscribed osteoporosis in the frontal and occipital regions; *b*, same view in 1935 showing further encroachment of osteoporosis on the strip of normal bone in the parietal region. The Paget lesions have increased in number and size; *c*, posteroanterior view in 1935.

CASE XIX (Case VI, Kasabach and Dyke, 1932: P. H. 223356). H. K., a Jewish salesman, now aged sixty-five, came to the Presbyterian Hospital in 1929 complaining of frequency and nocturia of two years' duration. In the course of pyelographic examination (1930), sclerotic lesions in the pelvis were observed, thought, at first, to be due to metastatic carcinoma. Films of the entire skeleton (1930), however, made it more probable that these were due to Paget's disease, of which evidence was found also in the lumbosacral spine, pelvis, femora, scapulae and humeri. Skull (Fig. 12, IX): Osteoporosis circumscripta of the frontal bone, together with thickening of the calvarium in the parietal region and numerous sclerotic areas typical of Paget's disease. Re-examination in 1931 showed an increase in the condensing process in the parietal and frontal regions. Re-examination in 1935 (Fig. 12, IX) revealed only a slight expansion of the osteoporotic area but a definite increase in the "cotton-wool" shadows which now involved the posterior part of the parietal regions. The remainder of the skeleton showed no definite advance of the Paget's disease since 1930.

Clinically, his symptoms were confined entirely to the genitourinary and gastrointestinal tracts. He has had no signs or symptoms referable to osteoporosis circumscripta of the skull or to Paget's disease elsewhere.

CASE XX (Case X, Kasabach and Dyke, 1932: P. H. 266060). L. L., a Jewish housewife, now aged fifty-three, first came to the Presbyterian Hospital in 1930 because of obesity. An incidental finding in the course of examination was a swelling of the anterior border of the right tibia. In 1920, she had developed severe pain in the right knee which had persisted for years despite a variety of treatment. In 1923, she first noted bowing of the tibia, which became progressively worse, with increasing difficulty in gait since 1925. Intermittent backache had been present for years. Roentgenographic examination (1930) disclosed Paget's disease of the right tibia. The skull in 1932 (Fig. 11, IV) showed osteoporosis circumscripta involving the frontal and the occipital bones. The outer table at the torcular Herophili appeared irregular and thinned. A number of small areas of increased density were seen along the posterior margin of the osteoporotic area in the frontal bone. Re-examination in 1935 (Fig. 11, IV) showed no definite change in the osteoporotic area but a considerable increase in the number of sclerotic bone deposits now scattered all over the cranium. The outer table of the frontal bone now appeared to be thinned and serrated. The involvement of the right tibia had progressed to the distal end, with increased expansion and bowing. The left tibia showed similar but less advanced changes. The remainder of the skeleton was not involved.

Clinically (1935), the bowing of the right tibia was of extreme degree causing a shortening of that leg and difficulty in gait. There was pain in both legs. Scoliosis and marked asymmetrical enlargement of the skull were apparent. She had occasional headaches but no other symptoms of the head. Examination of the blood unexpectedly yielded values (Table III) more consistent with hyperparathyroidism. (Parathyroid tumor was removed subsequently.)

CASE XXI (Case XI, Kasabach and Dyke, 1932: P. H. 271783). A. T., an American female, now aged seventy, came to the Presbyterian Hospital in 1930 complaining of pain in the right hip and in the right shoulder, present for several months. Examination was negative and the pain was ascribed to arthritis. Roentgenographic examination (1930) disclosed Paget's disease of the pelvis, lumbar spine and upper half of the femora. Skull: Osteoporosis circumscripta of the frontal bone chiefly on the left side (Fig. 12, X), extending inferiorly to the floor of the anterior fossa. Another area of osteoporosis was present in the squamous portion of the occipital bone extending obliquely upward to the parietal border. A number of sclerotic areas were present, especially in the frontal bone. Re-examination in 1935 (Fig. 12, X) showed no change in the frontal osteoporotic lesion, and only slight increase in the occipital lesion. Another small area of osteoporosis, about 3 cm. in diameter, had appeared at the posteroinferior border of the parietal bone on the left side. The areas of bone condensation had increased considerably in number and size, especially in the frontal and parietal areas. There was widening of the diploic spaces. The outer table of the frontal bone was somewhat thinner. The remainder of the skeleton showed no striking extension of the Paget's disease.

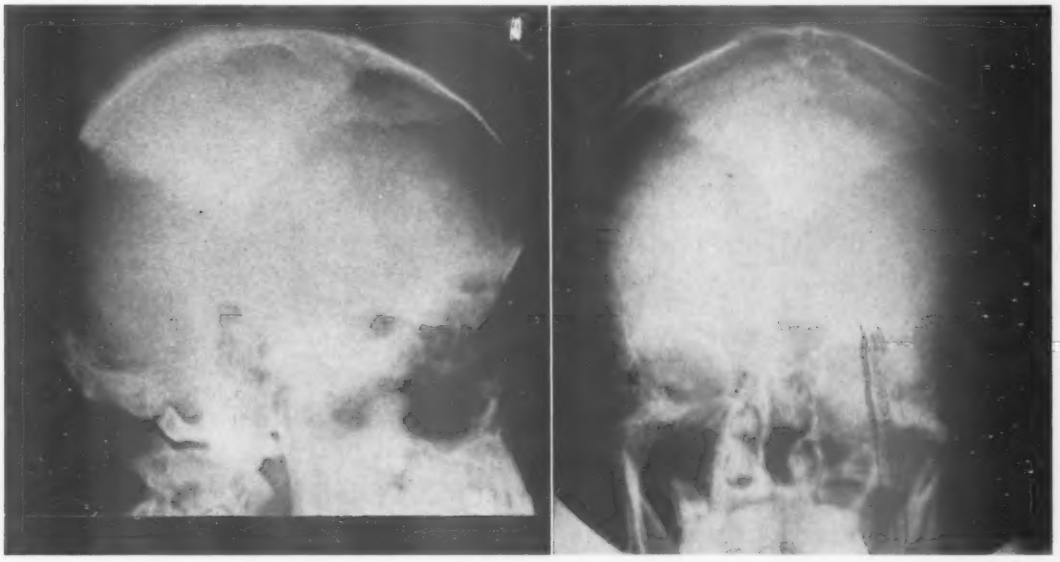
When last seen in 1935, no deformities were present. Intermittent pain in the lower back continued. No signs or symptoms referable to osteoporosis circumscripta of the skull had appeared.

Case xxii (Case 3, Schüller, 1929: N. I. 4256). P. F., Italian male, aged thirty, former professional boxer, was admitted to the Neurological Institute in September, 1925. For familial history see Case v (F. F., his brother). His symptoms began in 1923 with pain and impaired hearing of the left ear, later also on the right, so that he had become quite deaf. The presenting symptom on admission was intermittent headache (so severe as to make him cry out and beat his head against the wall), of six months' duration. During this period he had nausea and vomiting, and attacks of vertigo lasting about five minutes. Physical examination was essentially negative. No abnormalities of the head, no deformities of the extremities were apparent. The Wassermann test of the blood and spinal fluid was negative. The serum calcium was 10.8 mg. per cent.

Films of the skull (1925) revealed osteoporosis circumscripta involving the entire calvarium except the parietal and superior portion of the frontal bones (Figs. 8*a*, 8*b* and 11, 11). At the time, this was called generalized bone atrophy of the calvarium, with almost complete absence of calcium salts in the affected areas. Changes at the base of the skull resembling Paget's disease were pointed out. The diagnosis of atypical Paget's disease was made (Dr. C. W. Schwartz, 1925). Films of the remainder of the skeleton (1925) revealed osteitis deformans of two lower thoracic vertebrae, pelvis, and upper parts of both femora.

He was discharged unimproved in October, 1925, with the diagnosis Paget's disease and unexplained bone atrophy of the skull. Radiotherapy to the skull was advised but he did not return for treatment.

He was admitted to the Manhattan Eye, Ear and Throat Hospital in July, 1926, because of persistence of the symptoms described and also because of the appearance of several painful tumefactions of the calvarium in the left temporoparietal and occipital regions. These had been noted for the first time six weeks before and had increased in size. Trephination was performed and a section of the bony tumor was obtained. The sections were considered to be an "endothelioma" at the time but re-examination of restained sections showed osteogenic sarcoma (pathologic findings described under pathologic aspects). Decompression did not relieve the symptoms. Pain in lower back, hips, and legs with limp developed. Vision in both eyes became impaired. On August 26, 1926, the left eye became swollen. He became irrational and died the next day, at the Orange Memorial Hospital. Necropsy was not permitted.



a *b*

Fig. 8. Case xxii. *a*. Lateral view of the skull in 1925 showing very extensive osteoporosis circumscripta of the calvarium; *b*, posteroanterior view of the skull. (Courtesy of Dr. C. W. Schwartz.) (Case v and Case xxii are brothers.)

TABLE I

AGE DISTRIBUTION OF 46 CASES OF OSTEOPOROSIS CIRCUMSCRIPTA OF THE SKULL COMPARED WITH THAT OF 116 CASES OF PAGET'S DISEASE

Age in years	21–24	25–29	30–39	40–49	50–59	60–69	70–
Osteoporosis circumscripta: Age when diagnosed	1	1	9	13	12	8	2
Paget's disease: Age when diagnosed*	0	1	6	22	34	40	13

* Data on cases of Paget's disease from Gutman and Kasabach.[7]

FREQUENCY, AGE, SEX, FAMILIAL INCIDENCE

Including the 15 new cases presented here, 47 cases of osteoporosis circumscripta of the skull have been described in the literature to date. Our own experience leads us to believe, however, that the condition is not as rare as this figure would imply since many cases doubtless escape detection. The absence of external evidences of the disease in all cases and of symptoms in most cases explains why osteoporosis circumscripta of the skull has invariably been discovered accidentally; either in the course of routine skeletal examination in patients known to have Paget's disease, or as an incidental finding in roentgenographic examination of the skull for brain tumor, sinusitis, mastoiditis, etc.

The sex of the patient was stated in 45 cases, of whom 22 were males, 23 were females. The age was recorded in 46 instances (Table 1). With the exception of 2 cases, aged twenty-four and twenty-seven respectively, all patients were over thirty years of age when the disease was first discovered. The highest incidence occurred between the ages of forty and sixty. In only one instance, so far as known, were two members of the same family affected (Cases V and XXII of this paper).

ROENTGENOLOGIC ASPECTS

The importance of roentgenologic examination in the diagnosis of osteoporosis circumscripta of the skull is illustrated by the fact that all cases reported thus far were discovered as a result of the striking alteration in the roentgenographic appearance of the skull. Osteoporosis circumscripta is characterized by a marked diminution in density of one or more sharply outlined areas in the calvarium, of which a large proportion is often involved. The borders of the affected areas are serrated, undulating or curvilinear. Since transition zones of intermediate density are lacking, the contrast between the osteoporotic and the contiguous normal bone is striking. As may be demonstrated on roentgenograms taken in tangential views and by the preservation of trabecular architecture, the decrease in density of the involved portion of the calvarium is not due to bone destruction but is the result of decalcification. In the majority of instances, the affected region of the skull is of the same thickness as the adjacent normal bone, but occasionally localized expansion or, rarely, slight thinning may be observed. The outer table and the diploe are likely to be more extensively involved than the inner table, which often remains intact. Vascular markings and suture lines within the involved areas are usually well preserved. There is no relation between the boundaries of the osteoporotic areas and cranial suture lines. As shown in Table II, the frontal region is the most common site of osteoporosis circumscripta of the skull, the occipital region being next in frequency. Initial lesions confined to the parietal or temporal bones are rare. In 10 instances, practically all of the bones of the calvarium were involved.

As the number of cases observed has grown and the time they have been followed has increased, it has become possible to reconstruct more satisfactorily the man-

TABLE II

INCIDENCE OF BONES AFFECTED IN 47 CASES OF OSTEOPOROSIS CIRCUMSCRIPTA OF THE SKULL (FROM THE LITERATURE, INCLUDING THE PRESENT SERIES OF 15 NEW CASES)

	No.
Frontal bone only, or extending to the temporal or parietal bones, or both	21
Occipital bone only, or extending to the parietal bones	9
Discrete foci in both frontal and occipital bones	4
Very extensive, involving practically the entire calvarium	10
Parietal bones only	2
Temporal bone only	1

ner in which the bizarre patterns seen in advanced cases develop. The disease would seem to begin with the appearance of small, discrete, round or oval, sharply circumscribed areas of osteoporosis usually in the frontal or occipital regions, such as described by Weiss,[30] Meyer-Borstel[15] and by ourselves (Figs. 1, 2, 4 and 7). These areas increase in extent over a period of years. Where the initial focus is in the frontal region, the temporal, parietal and occipital bones are successively involved until a picture such as Figure 1*b* is presented. The border of the affected area is usually curvilinear, with the concavity towards the frontal region. In other instances (Figs. 11, v and 12, viii), the initial focus is in the occipital region, expanding upwards and forwards to involve adjacent bones, the border usually presenting its concavity towards the occiput. More frequently, however, multiple foci appear independently and simultaneously, usually in both the frontal and occipital regions. Each lesion expands until the affected areas become confluent, producing pictures such as those illustrated in Figures 2*b*, 4*b*, 8*a* and 8*b*. Since the initial foci usually arise near the base, a residual patch of normal bone, tapering towards the base of the skull, often remains in the parietal region near the vertex. The development of such a pattern is shown schematically in Figure 10. Eventually, the whole skull may become osteoporotic, and as the contrasting densities of normal and osteoporotic bone disappear, recognition of the condition may be difficult or impossible. We have encountered several instances in which sclerot-

FIG. 9. Reproduction of an illustration in Schmorl's article[22] on Paget's disease, an example of "hemorrhagic infarction of the calvarium." It will be appreciated that a roentgenogram of this skull would give a picture closely resembling a far advanced osteoporosis circumscripta such as seen in our cases, Figures 2*b*, 4*b*, 7*b* and 8*b*.

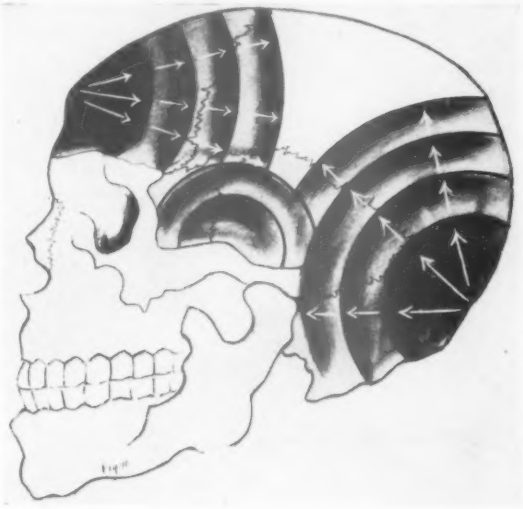


FIG. 10. A diagram of the development of osteoporosis circumscripta arising from three independent foci to produce a pattern characteristic of the disease in advanced stages. Arrows indicate the direction of the expansion, involving more and more of the normal bone.

ic Paget lesions were present in various parts of the skeleton, but the skull exhibited diffuse osteoporosis of the calvarium; possibly representing the end-stage of this process.

Expansion of the initial foci may be unilateral or bilateral; large areas of osteoporosis circumscripta usually involve both sides of the skull, though not necessarily symmetrically. In Case v, the left side of the skull was principally affected in 1932 but by 1935 much of the right side, as well

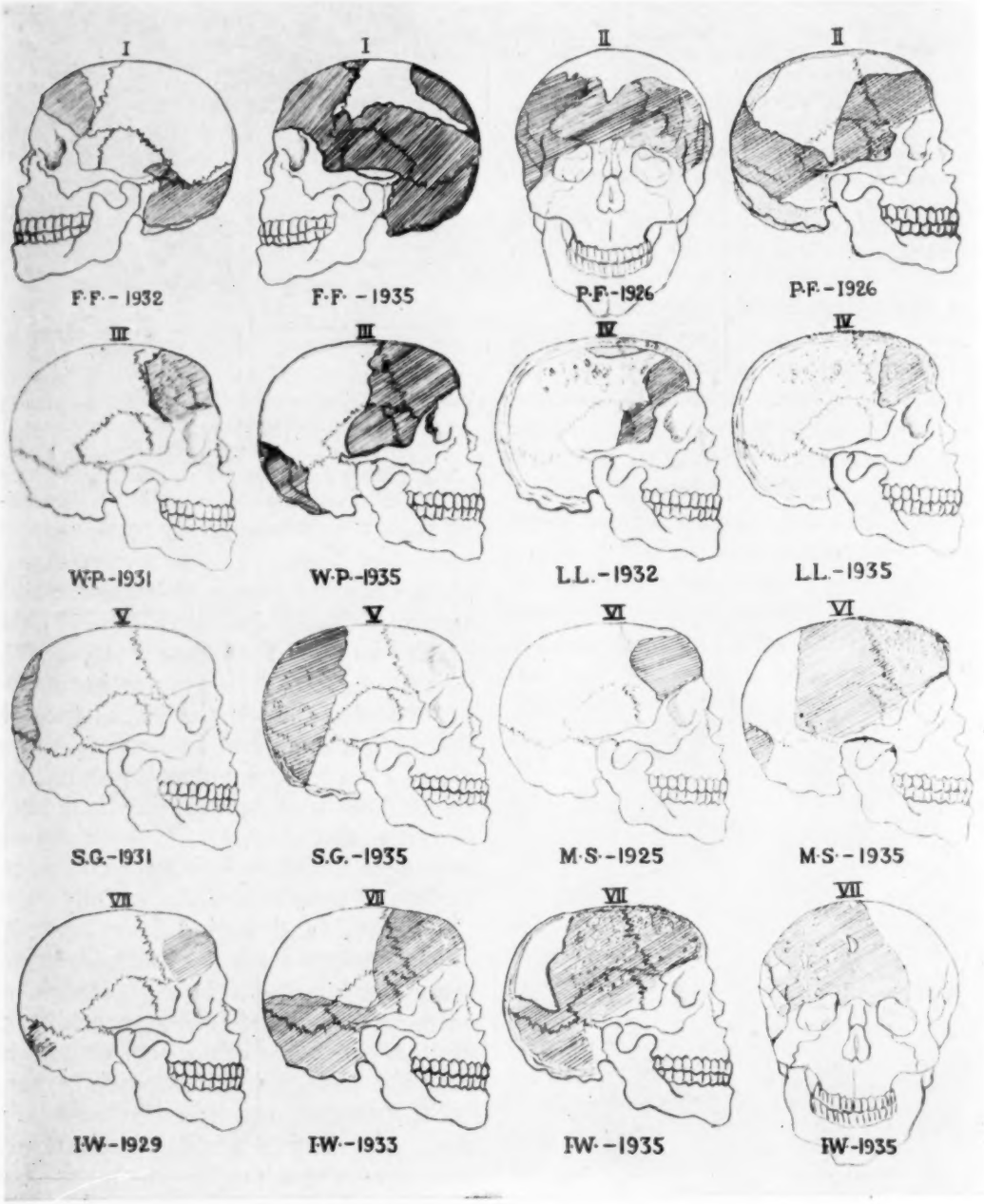


FIG. 11. Diagrammatic reproduction of roentgenograms of the skull of patients described in the text, including those not illustrated by roentgenograms because of lack of space.

as the whole of the left side, was involved. The rate at which osteoporosis circumscripta develops is variable. In exceptional cases, expansion is relatively rapid and may be apparent in roentgenograms taken at yearly intervals. In Cases v (Figs. 4*a* and 4*b*) and xviii (Figs. 7*a*, 7*b* and 7*c*), the major portion of the calvarium was affected within periods of three and four years respectively. In other instances (Case xxi), no progress of the lesion could be made out over a period of five years. In

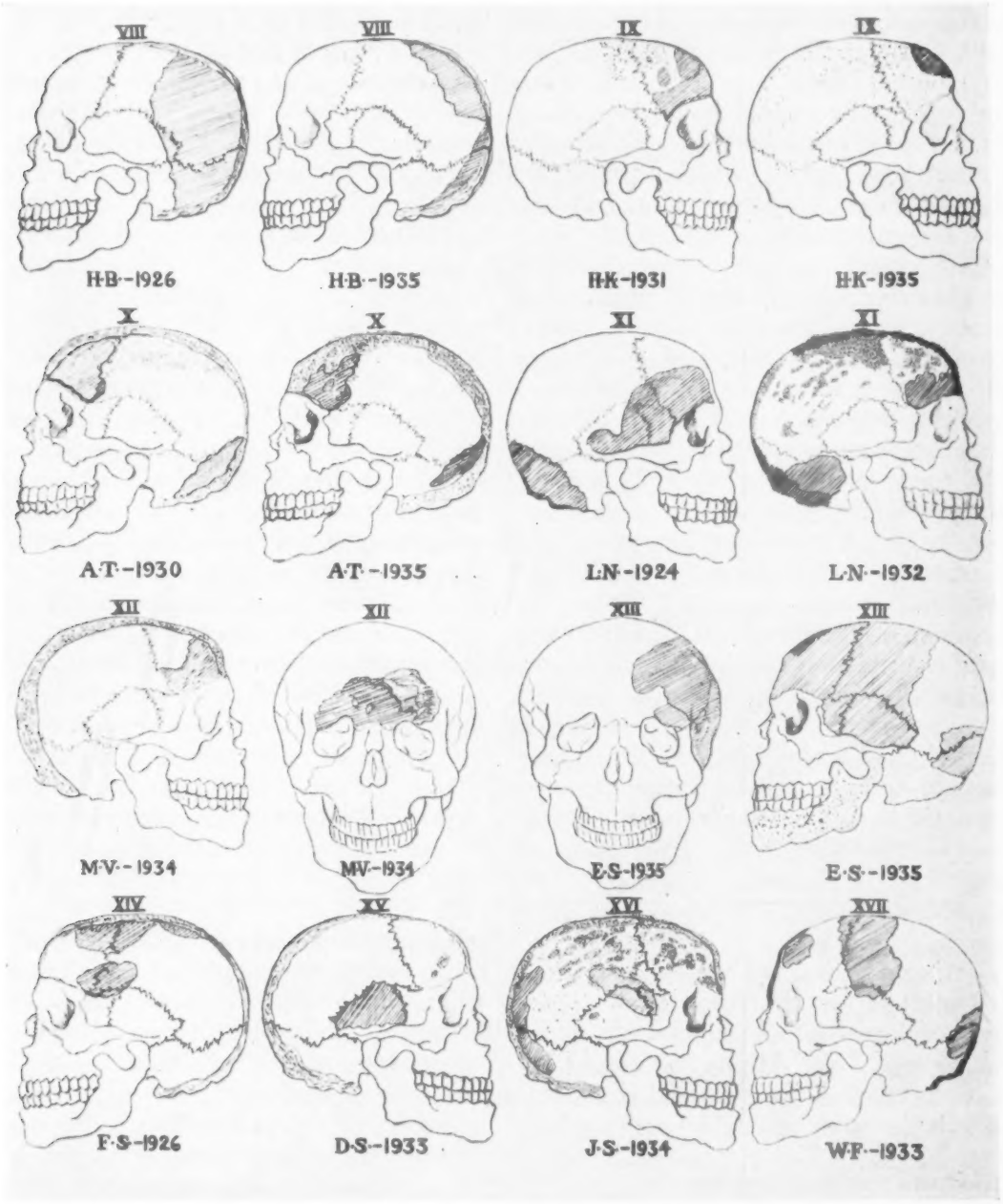


Fig. 12. Diagrammatic reproduction of roentgenograms of the skull of patients described in the text, including those not illustrated by roentgenograms because of lack of space.

2 instances (Cases II and XIX), regression of the osteoporotic areas appeared to be taking place.

Osteoporosis circumscripta seems to select chiefly the membranous bones of the skull. Usually, the increased radiability of the affected bones fades indefinitely into the apparently normal bone densities at the base. Non-involvement of the base may be more apparent than real, however, because of less satisfactory visualization of contrasting densities.

With respect to differential diagnosis, the characteristic features of osteoporosis circumscripta of the skull described above are so distinctive that in its advanced form, when a large portion of the calvarium is involved, confusion is unlikely. The roentgenographic appearance of the skull when only small, solitary or multiple areas of osteoporosis circumscripta are present however, may be simulated by other skull affections: cholesteatoma,[2] xanthoma,[27] mucoceles or retention cysts, hyperparathyroidism,[8*] localized osteitis fibrosa cystica,[17] multiple myeloma, metastatic carcinoma, meningioma, syphilitic gumma, chronic osteomyelitis, fungus infections of the skull, and Ewing's tumor.[18] In all these diseases, however, circumscribed areas of decreased bone density are due to destruction of bone, whereas in osteoporosis circumscripta decalcification only occurs, the architecture of the calvarium remaining intact.

Passing mention only need be made of real or apparent decreased bone density due to large pacchionian depressions; thin-walled, large lateral sinuses; thin-walled squama of the temporal bones, particularly in overexposed roentgenograms; congenital or acquired (postoperative or traumatic) cranial defects; and to aeroceles, traumatic or post-infectious.

The frequent association of osteoporosis circumscripta of the skull with Paget's disease, to be discussed later, provides another aid in diagnosis. Osteoporosis circumscripta should not be confused with the areas of rarefaction often seen surrounding the sclerotic "cotton-wool" shadows in Paget's disease of the skull or with bone destruction due to sarcoma arising from Paget bone.

CLINICAL ASPECTS

None of our cases of osteoporosis circumscripta of the skull was diagnosed or even suspected clinically, and this applies, so far as we are aware, to the cases in the literature. The difficulties in the way of clinical recognition of the condition are readily appreciated when it is remembered that external evidences of the affection were absent in all cases and symptoms referable to the disease were lacking in most patients recorded to date.

Irregularities of the contour of the skull detectable by inspection or by palpation do not occur except where due to associated Paget's disease of the skull in its more advanced stages. It is said[25,30,31] that an unusual tympanitic note may be elicited by percussion over osteoporotic areas, but this sign is often absent (refs. 1, 24, and also personal observations).

A variety of symptoms was present in the 47 cases under consideration. For the most part, they were obviously not related to osteoporosis circumscripta of the skull: pain in an extremity, deformity or difficulty in gait shown to be due to Paget's disease of the long bones or of the spine; or asthma, pernicious anemia, genitourinary infections, and the like.

Twenty cases exhibited symptoms referable to the head, predominantly pain in the head variable in location, type, duration and intensity. In most instances, this was an indefinite dull frontal or occipital headache, of moderate intensity and ir-

* In hyperparathyroidism, the skull occasionally presents not the fine, granular mottling usually seen, but one or more bone cysts similar to those found in the bones of the extremities.[28] The roentgenologic, clinical and biochemical changes in hyperparathyroidism are so characteristic, however, that differentiation is not difficult. In several of our cases, sclerotic Paget lesions developed within areas of osteoporosis circumscripta in the form of diffuse, homogeneous mottling quite different in appearance from the usual "cotton-wool" picture with more or less distinct bone islands. The changes were not unlike those seen in some cases of hyperparathyroidism where the skull mottling is more coarsely granular (ref. 8, see Case 2, Fig. 4).

regular occurrence. The majority of these cases also had Paget's disease of the skull, many were arteriosclerotic, some had arterial hypertension, one had pansinusitis. As these conditions are common causes of headache, they must be regarded as the more probable etiology, where present. In 8 cases, the headache was more severe and was associated with other symptoms (vertigo, vomiting, impaired vision or hearing, drowsiness, epileptiform attacks) sufficiently pronounced to suggest brain tumor. In one instance, these symptoms proved to be due to a large cyst of ventricular origin;[20] in another, to hyperinsulinism (Case XVII); in 2 others, advanced Paget's disease of the skull was present. In the remaining cases, 2 of whom came to autopsy, no lesion other than osteoporosis circumscripta of the skull was discovered to which the symptoms could be ascribed. Three additional cases suffered from severe unilateral lancinating or burning pain suggesting trigeminal neuralgia or migraine. It is possible that osteoporosis circumscripta of the skull was the cause of symptoms in these cases, a possibility further suggested by the therapeutic results obtained by radiotherapy in one such instance.[34] The majority of cases of osteoporosis circumscripta of the skull, however, appear to be asymptomatic.

PATHOLOGIC ASPECTS

The results of pathologic examination of biopsy obtained from an area of osteoporosis circumscripta, as reported by Sosman,[26] have already been referred to as providing the first published evidence relating osteoporosis circumscripta to Paget's disease. A biopsy specimen of the frontal bone obtained from the case reported by Guillain, Ledoux-Lebard and Lereboullet presented a microscopic picture thought to be similar to von Recklinghausen's disease. In Case XXII of this series (P. F.), trephination was attempted on the left side, posteriorly and superiorly to the auricle but was unsuccessful because of hemorrhage due to dilatation of the diploic veins. A second attempt, inferiorly, yielded several fragments of friable, hemorrhagic tissue containing some spicules of bone. The bone was rather soft, in some areas pulpy. Dr. A. M. Pappenheimer described the sections as those of "a tumor consisting of deeply staining cells, some fusiform, some polygonal. In many places they are separated by parallel bands of pink-staining hyaline material resembling osteoid, in the central portions of which calcium is deposited in granular form. In a few areas, well-formed bone trabeculae with wide osteoid margins are seen, some with mature bone corpuscles. The tumor varies in cellularity and in the amount of osteoid in different areas. Diagnosis: Osteogenic sarcoma." This is the only instance we could find of osteogenic sarcoma arising from an area of osteoporosis circumscripta, a circumstance of particular interest because of the well-known predisposition of Paget bone towards this type of tumor.

Four cases[4,20,25] of osteoporosis circumscripta have come to autopsy, revealing a consistent and characteristic alteration in the gross appearance of the skull. It was found that the areas presenting the roentgenographic picture of osteoporosis circumscripta were dark red in color, contrasting sharply with the adjacent normal bone. The line of demarcation was irregular and sharply defined, corresponding with that seen in the roentgenogram. No difference other than that of color was apparent on gross inspection between the normal and affected bone, the surface of which was smooth and of the same thickness as the adjacent normal bone. On sectioning, however, it was obvious that the reddish areas were decalcified, since, in Schüller's cases, they could be cut easily with a knife. Inspection of the cut edge of the affected bone revealed loss of differentiation and the presence of a homogeneous, porous bony structure. Schellenberg[20] comments on the increased blood content of the bone as evidenced by its color and by the abundance of bloody fluid easily expressed.

Histological examination of sections

from areas of osteoporosis circumscripta showed changes suggesting Paget's disease in Schüller's cases; details are not given. Schellenberg gives a full account of the findings in his case. The compact bone constituting the tables had largely disappeared leaving an irregular network of fine trabeculae, many lined with osteoblasts, but the newly formed bone was obviously poor in calcium. The intertrabecular spaces were filled with loose fibrous tissue, in some areas infiltrated with round cells. Schellenberg classified the changes as osteitis fibrosa, using the term in the more general sense in which it was employed by Looser. The process, he felt, was still relatively fresh and active, possibly an early stage of Paget's disease. Erdheim's case[4] was minutely studied histologically and interpreted as early Paget's disease.

We were impressed by the similarity between these accounts of the pathology of osteoporosis circumscripta of the skull and the description given by Schmorl[21,22] of a condition called by him "hemorrhagic infarction of the calvarium." Schmorl's series included 7 cases, 5 of them associated with typical Paget's disease elsewhere in the skeleton.[21] These skulls exhibited dark red areas sharply demarcated from the bordering normal bone. The inner and outer tables as well as diploe were involved. The anterior and occipital portions of the calvarium may be affected; in no instance was there any relation between the distribution of the affected area and suture lines. Schmorl gives a precise account of the histologic findings which, with the exception of the greater emphasis placed upon the hemorrhagic manifestations, resembles that of osteoporosis circumscripta given by Schellenberg.

Schmorl does not refer to osteoporosis circumscripta of the skull nor do those concerned with osteoporosis circumscripta allude to Schmorl's pathologic observations. It seems to us very likely, however, that the two conditions are identical. Comparison of Schmorl's illustration (reproduced here, Fig. 9) with that of some of our roentgenograms (Figs. 2, 4, 7 and 8) is instructive in this connection.

BIOCHEMICAL ASPECTS

The blood of 18 cases of osteoporosis circumscripta of the skull was analyzed for calcium, inorganic phosphorus, phosphatase activity and non-protein nitrogen (Table III).* The serum calcium was found to be within normal limits except in Cases W. P. and L. L., in which the values were somewhat elevated. Case L. L. also showed a low serum inorganic phosphorus, the only value deviating from the normal. This patient, whose blood chemistry is more suggestive of hyperparathyroidism, is being further investigated.† Serum phosphatase activity was within normal limits or only slightly increased in those cases in which osteoporosis circumscripta was not associated with Paget's disease in the skull or elsewhere (Cases 1–5). Where typical Paget lesions were also present, however (Cases 8–18), serum phosphatase activity was consistently and consideraby above the maximum normal value of 4.0 Bodansky units per 100 c.c. This finding is in accord with the increased phosphatase activity observed in polyostotic Paget's disease not associated with osteoporosis circumscripta of the skull, as first shown by Kay[12] and subsequently confirmed by others.[9] The increased phosphatase activity noted in our cases of osteoporosis circumscripta associated with Paget's disease is due to the presence of sclerotic Paget lesions and not to osteoporosis circumscripta of the skull.[6] In this connection it is interesting to note (Table III) that in Case I.W., in which there was a considerable increase in the osteoporotic lesion from 1933 to 1935, no increase in the level of serum phosphatase activity occurred in the same period. In Case W. P., on the other hand, the development of sclerotic lesions in the skull was associated with a rise in serum phosphatase.

* For methods, see Gutman, Gutman and Kasabach.[6]

† A parathyroid tumor was subsequently removed. Case to be reported in full elsewhere.

TABLE III

SERUM CALCIUM, INORGANIC PHOSPHORUS, PHOSPHATASE ACTIVITY AND NONPROTEIN NITROGEN IN 18 CASES OF OSTEOPOROSIS CIRCUMSCRIPTA OF THE SKULL (ASSOCIATED WITH PAGET'S DISEASE IN 11 CASES)

					Serum				
No.	Case	Age	Sex	Date	Phosphatase Bodansky units per 100 c.c.	Ca mg. per cent	Inorg. P mg. per cent	N.P.N. mg. per cent	Remarks
1	D. S.	35	♂	11- 3-33	1.6	8.9	4.2	52	Osteoporosis circumscripta only
2	H. W.	60	♂	9-13-35	2.0	10.6	3.6	32	Osteoporosis circumscripta only
3	S. G.	45	♀	10- 9-35	4.5	11.0	3.4	30	Osteoporosis circumscripta only
4	W. P.	38	♂	8-25-34	4.6	—	2.7	—	Osteoporosis circumscripta only
				9-25-35	7.3	11.6	2.4	27	Beginning sclerosis in skull
5	J. G.	63	♂	12-17-34	5.4	9.7	2.6	29	Osteopososis circumscripta only
6	M. V.	31	♀	2- 5-35	7.8	9.6	3.0	—	Osteofibroma (?) of maxilla
7	G. P.	40	♂	3- 1-34	14.9	10.8	3.7	42	Bone cyst, tibia
8	J. S.	59	♂	11-27-34	23.0	10.8	3.6	29	With typical Paget's disease
9	M. S.	75	♀	3-25-34	24.2	9.8	3.0	—	With typical Paget's disease
				10-31-34	14.6	10.1	3.5	30	
				10-24-35	25.4	11.4	3.7	42	
10	L. L.	48	♀	9- 8-30	—	10.9	—	—	With typical Paget's disease
				10- 1-35	31.4	12.8	1.9	29	and hyperparathyroidism.
11	H. B.	74	♀	10-30-34	32.1	10.5	3.2	32	With typical Paget's disease
				10- 9-35	26.7	10.8	3.3	27	
12	H. K.	64	♂	1- 9-32	—	11.0	4.2	—	With typical Paget's disease
				6- 4-34	32.5	11.5	3.2	31	
				10-10-35	21.8	10.9	3.5	31	
13	M. S.	54	♀	6-27-34	34.6	10.2	3.8	32	With typical Paget's disease
14	I. W.	58	♀	8-29-33	36.5	10.1	3.8	36	With typical Paget's disease
				8-31-33	—	9.8	—	—	
				9-22-35	33.0	10.1	3.4	28	
15	A. T.	70	♀	4-22-35	40.1	—	3.8	44	With typical Paget's disease
16	W. F.	43	♂	12-29-33	45.7	10.8	3.5	—	With typical Paget's disease
				9-17-35	61.8	9.9	3.4	31	
17	F. F.	36	♂	10- 2-35	52.5	10.2	3.2	31	With typical Paget's disease
18	E. S.	37	♀	3- 1-35	57.9	9.8	3.6	25	With typical Paget's disease

DISCUSSION

Four aspects of the problem presented by osteoporosis circumscripta of the skull will be considered: (1) etiology; (2) relation to Paget's disease; (3) relation to bony tumors of the jaw; (4) treatment.

(1) The etiology of osteoporosis circumscripta is unknown but a number of possibilities can be excluded. Hereditary factors are unimportant since so far as known, two members of the same family were affected in only one instance. Clinical signs or symptoms of infection were lacking in our cases, except where due to obviously unrelated causes. The results of pathologic examination reported in the literature likewise rule out infection. The blood Wassermann test was positive in only one of our cases. Endocrine imbalance seems unlikely because of the localized character of the bone changes. Our results on the determination of serum calcium, inorganic phosphorus and phosphatase activity do not implicate the parathyroid glands, except in Case xx. A history of trauma was obtained in only 3 instances and even in these the relation to osteoporosis circumscripta seems doubtful.

If, as seems probable, osteoporosis circumscripta of the skull is identical with the condition described by Schmorl[21] as "hemorrhagic infarction of the calvarium," then the underlying cause might be a disturbance in the circulatory system of the affected areas, the osteoporosis being secondary. It will be recalled that the calvarium is provided with an elaborate vascular system.[14] There is a dual blood supply arising from the meningeal and pericranial arteries which anastomose freely in the diploe, and empty into sinusoid-like spaces, draining chiefly into large diploic veins. As Merkel[14] pointed out, the diploic circulation is analogous in many ways to that of the spleen (where hemorrhagic infarcts are not uncommon). It appears, therefore, that the mechanics of the vascular bed of the calvarium would permit of the occurrence of hemorrhagic infarction.

That the lesions described by Schmorl really are hemorrhagic infarcts, however, has not yet been demonstrated. It remains to be determined, by appropriate pathologic studies, whether the *vascular* or the *bony* changes constitute the primary pathology. Schmorl[21] was unable to find gross obstruction of the larger arteries or veins of the head in his cases of hemorrhagic infarction of the calvarium to account for the engorgement of diploic vessels seen in sections. He felt certain, however, that simple hypostasis could be ruled out.

(2) The relation of osteoporosis circumscripta of the skull to Paget's disease is of interest not only with respect to the pathogenesis of osteoporosis circumscripta but also because of certain implications regarding the etiology and pathogenesis of osteitis deformans. That such a relation exists, there can be little doubt. Direct pathologic evidence is available, since, as stated above, material from osteoporotic areas obtained by biopsy or at post-mortem examination has on several occasions been interpreted as Paget's disease. Further, 32 of the 47 cases of osteoporosis circumscripta of the skull described in the literature to date were shown to have typical sclerotic Paget lesions somewhere in the skeleton; and in 8 of the remaining cases, only the skull was examined so that the possibility of Paget's disease elsewhere was not excluded. In 18 instances, the skull was the site of both osteoporosis circumscripta and the "cotton-wool" shadows typical of Paget's disease.* Moreover, as Kasabach and Dyke[11] first showed, skulls exhibiting only osteoporosis circumscripta, if followed for a sufficient period of time, develop sclerotic Paget lesions in or about the osteoporotic areas. Four such instances (Cases I, II, III and IV) are included in the present series. In Case I, Paget's disease was found to have developed within two years; in Case II, within nine years; in Case III, within seven years. In Case IV, the "cotton-wool" changes were so extensive as to have quite obliterated all vestiges of osteoporosis circumscripta clearly present eight years before (Fig. 3*b*); if the earlier films had not been available, the presence of osteoporosis circumscripta might easily have been overlooked. This experience leads us to believe that some cases of advanced Paget's disease of the skull may have been preceded by osteoporosis circumscripta of the skull which is no longer in evidence, having been entirely blotted out by the development of dense sclerotic bone.

In fact, all indications point to a regular sequence from osteoporosis circumscripta of the skull to osteitis deformans of the skull. It has not been proved, however, that all cases of osteoporosis circumscripta of the skull ultimately develop Paget's disease. In one such instance, described by Guillain et al., the patient was under observation only a few months. In Weiss' case, followed for three years, sclerotic bony islands did not appear. Our own experience would suggest, however, that sufficient time may not have been allowed to elapse, since expansion of osteoporotic

* Guillain et al., reporting a single case, are of the opinion that in the cases reported in the literature in which Paget's disease and osteoporosis circumscripta were present together in the same skull, the diagnosis of osteoporosis circumscripta was not convincingly established.

areas may be arrested for long periods, five years in Case XIX. It seems justifiable to state that patients exhibiting osteoporosis circumscripta of the skull will probably develop Paget's disease ultimately and should be followed with this in mind.

With respect to the precise nature of the relation between osteoporosis circumscripta and Paget's disease, opinion is divided. As pointed out by Weiss,[31] the assertion that osteoporosis circumscripta is an early, obligatory phase in the development of Paget's disease, one through which all Paget bone must pass,[15] is not borne out by experience. We have had the opportunity to examine 105 roentgenograms of the skull in 116 cases with skeletal changes typical of Paget's disease.[7] Of this number, 82 presented the typical picture of osteitis deformans of the skull, many still in relatively early stages, but osteoporosis circumscripta was recognized in only 20 cases. If osteoporosis circumscripta is an obligatory phase in the development of Paget's disease, it is difficult to understand why it is not more commonly seen. As regards osteoporosis circumscripta initiating sclerotic Paget lesions in bones other than the skull,[15] in our studies on 116 cases of Paget's disease[7] no sharply circumscribed areas of osteoporosis definitely identifiable as osteoporosis circumscripta were found except in the skull. Decalcification in various parts of the skeleton of persons affected with Paget's disease is not uncommon, and coarse trabeculations frequently appear in what seems to be osteoporotic bone, but these conditions do not resemble osteoporosis circumscripta. The structureless area of decreased density in a tibia illustrated by Meyer-Borstel as such an instance (described also by Eisler),[3] was encountered by us several times. Schmorl has studied this type of variation of bone architecture in Paget's disease[21] and found it to be due to an unusual accumulation of osteoid tissue; a picture quite different from that seen in osteoporosis circumscripta. Histologic studies in general[21,22] do not support the view that osteoporosis circumscripta regularly precedes the development of the "mosaic pattern" characterizing Paget's disease. Ordinarily, absorption of bone is associated with increased bone formation, or so soon superseded by it, that extensive areas of osteoporosis are not encountered.

The data at hand seem to us more consistent with the view that osteoporosis circumscripta of the skull is a relatively independent, though related, precursor of Paget's disease. Apart from the fact that osteitis deformans is associated with osteoporosis circumscripta only in the skull, and even there in only a small proportion of cases, there are a number of observations which militate against the view that osteoporosis circumscripta is simply an early stage of Paget's disease. Osteoporosis circumscripta begins, usually, in the frontal or occipital bones near the base, whereas early Paget lesions are seen most commonly in the region of the vertex. Osteoporosis circumscripta may persist for years without Paget's disease. When sclerotic lesions appear, they sometimes develop wholly or in part in that portion of the calvarium which is not osteoporotic (see Figs. 11 and 12, and Weiss[31]). Where osteoporosis circumscripta and Paget's disease are both present, follow-up studies show that the osteoporotic areas may expand rapidly while the sclerotic bone islands remain essentially unchanged (Case XVIII), or the Paget lesions may show relatively rapid growth while the osteoporotic areas are arrested (Case XIX).

Our conclusions are in general agreement with the opinions expressed by Sosman,[26] Weiss,[31] Kasabach and Dyke,[11] and others.[1,13,25*]

(3) In 2 instances in our series (Cases VIII and IX), osteoporosis circumscripta was associated with bony tumors of the jaw, variously interpreted as osteitis fibrosa cystica, Paget's disease, osteoma and osteofibroma. This association has occurred too often to be without significance.[1,13] It is

* Erdheim in a recent article[4] expresses the opinion that osteoporosis circumscripta is an early stage of Paget's disease.

interesting to note that, almost without exception, the bony tumor involved the upper jaw and that the frontal bone was invariably the site of osteoporosis circumscripta in such cases, i.e., the adjacent portion of the calvarium, most likely to be affected by local mechanical or circulatory embarrassment.

In 1923, Moore (see his Case III, Fig. 14) described a case of Paget's disease with bony tumor of the left maxilla and noted a rarefaction of the frontal region of the skull which appears to be identical with what is now known as osteoporosis circumscripta of the skull. Schüller's first case[24] of osteoporosis circumscripta presented a tumor of the right upper jaw, regarded as a questionable sarcoma. In 1927, Whitlock (ref. 33, Figs. 14–18) described a case of tumor of the right upper jaw, biopsy of which was interpreted as adamantinoma, with changes in the vault thought to be due to extension of the tumor but typical of osteoporosis circumscripta in appearance. The case recorded by Le Fort and Moreau[13] likewise presented an osteoma-like mass involving the left upper jaw, invading the antrum, and diagnosed roentgenographically as leontiasis ossea. In the case described by Bertel and Provvisionato,[1] the presenting complaint was deformity of the face due to a bony tumor of the right upper jaw. It was shown in this instance that osteoporosis circumscripta of the skull did not develop until after the bony tumor of the jaw had been present for a number of years. These authors consider the association of osteoporosis circumscripta of the skull with bony tumors of the jaw distinctive enough to warrant segregation under the designation "scleromalacia."

(4) Since osteoporosis circumscripta of the skull is usually asymptomatic, treatment is unnecessary. In one case presenting severe headache and vertigo, Zaccaria[34] was able to ameliorate the symptoms by radiotherapy to the affected area of the skull; definite recalcification was observed in the osteoporotic bone following treatment.

SUMMARY AND CONCLUSIONS

1. Fifteen new cases of osteoporosis circumscripta of the skull are presented, together with follow-up reports on 7 cases previously recorded. The progress of the disease has been studied for periods of three years or longer in 11 cases, in 8 of which the observation period extended from five to thirteen years. The characteristics of the roentgenologic appearance of the skull in these cases are described.

2. Almost all phases of the disease are represented in this series. In reconstructing the development of the bizarre patterns seen in advanced stages, it would appear that the disease begins as small, rounded, circumscribed areas of osteoporosis often in the frontal region near the base, sometimes in the occipital region, occasionally elsewhere. These areas expand over a period of years until the major portion of the calvarium or the entire calvarium is involved. Frequently, several foci appear independently in both the frontal and occipital regions. As these areas expand, they become confluent. Since the initial foci originate near the base, the last remnant of normal bone is likely to be in the parietal region posterior to the vertex, producing a characteristic design in the lateral roentgenogram of the skull.

3. In 32 of the 47 cases in the literature, including 11 of our 15 new cases, osteoporosis circumscripta of the skull was associated with typical Paget's disease somewhere in the skeleton. In 18 cases from the literature, including 7 of our own, the skull was the site of both osteoporosis circumscripta and the "cotton-wool" shadows characteristic of Paget's disease.

4. In 5 cases presenting only osteoporosis circumscripta of the skull, follow-up studies revealed the development of Paget's disease in or about the osteoporotic areas within two to eight years. This appears to be a regular sequence, though the areas of osteoporosis circumscripta may remain essentially unchanged for a number of years.

5. The clinical aspects of the cases of osteoporosis circumscripta of the skull in

the literature are summarized. Most cases are asymptomatic. In some, headache, vertigo, migraine and epileptiform attacks may have been related to osteoporosis circumscripta. With regard to age incidence, the data on osteoporosis circumscripta of the skull are similar to those on Paget's disease. The peak age incidence, however, occurs two decades earlier than in Paget's disease.

6. Chemical analyses of the blood were carried out in 18 cases. With one exception, the serum calcium and inorganic phosphorus were within normal limits. Serum phosphatase activity was essentially normal in osteoporosis circumscripta but was characteristically elevated where typical Paget's disease was also present.

7. The results of pathologic examination of bone from osteoporotic areas, as recorded in the literature, are reviewed. It is pointed out that the findings are similar to, and probably identical with those described in what Schmorl called "hemorrhagic infarction of the calvarium." Osteoporosis circumscripta of the skull might, accordingly, prove to be due to a primary disturbance in the diploic circulation, the decalcification (osteoporosis circumscripta) and subsequent sclerosis of the calvarium (Paget's disease) being secondary phenomena. There is, however, no definite evidence now available to indicate whether the *vascular* or the *bony* changes are primary.

8. The relation between osteoporosis circumscripta of the skull and Paget's disease of the skull is discussed. It is believed that osteoporosis circumscripta is not an obligatory, early phase of Paget's disease, but a precursor of Paget's disease or, in a broad sense, an atypical form of Paget's disease, as suggested by Sosman. Its occurrence solely in the skull is thought to be related chiefly to the peculiarities characterizing the diploic circulation and the cranial architecture.

9. The association of osteoporosis circumscripta of the skull with bony tumors of the maxillary bone as noted in 7 cases in the literature, including 2 of our own, is discussed. It is pointed out that the bone tumor almost invariably involved the upper jaw and that the adjacent frontal bone, in such cases, was the site of osteoporosis circumscripta.

We wish to acknowledge the kindness of Dr. C. W. Schwartz and Dr. C. G. Dyke in placing Cases IV and XXII at our disposal. We are indebted to Dr. Ross Golden for advice and guidance.

REFERENCES

1. BERTEL, G., and PROVVISIONATO, A. Aspetto di morbo di Paget a carico del mascellare in un caso di osteoporosi circoscritta del cranio (Schüller). *Stomatol.*, 1934, *32*, 371–410.
2. CUSHING, H. A large epidermal cholesteatoma of the parieto-temporal region deforming the left hemisphere without cerebral symptoms. *Surg., Gynec. & Obst.*, 1922, *34*, 557–566.
3. EISLER, F. Ein seltener Fall von Pagetscher Knochenerkrankung (Ostitis deformans). *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1922, *29*, 311–315.
4. ERDHEIM, J. Ueber die Genese der Paget'schen Knochenerkrankung. *Beitr. z. path. Anat. u. z. allg. Path.*, 1935, *96*, 1–60.
5. GUILLAIN, G., LEDOUX-LEBARD, R., and LEREBOULLET, J. Ostéoporose circonscrite du crâne (maladie de A. Schüller). *Bull. et mém. Soc. méd. d. hôp. de Paris*, 1935, *51*, 777–787.
6. GUTMAN, A. B., GUTMAN, E. B., and KASABACH, H. H. Serum phosphatase activity in 17 cases of osteoporosis circumscripta of the skull. *Proc. Soc. Exper. Biol. & Med.*, 1935, *33*, 295–297.
7. GUTMAN, A. B., and KASABACH, H. H. Paget's disease (osteitis deformans); analysis of 116 cases. *Am. J. M. Sc.*, 1936, *191*, 361–380.
8. GUTMAN, A. B., SWENSON, P. C., and PARSONS, W. B. Differential diagnosis of hyperparathyroidism. *J. Am. M. Ass.*, 1934, *103*, 87–94.
9. GUTMAN, A. B., TYSON, T. L., and GUTMAN, E. B. Serum calcium, inorganic phosphorus and phosphatase activity in hyperparathyroidism, Paget's disease, multiple myeloma and neoplastic disease of bones. *Arch. Int. Med.*, 1936, *57*, 379–413.
10. HALLERMANN, W. Zur Kenntnis der Ostitis deformans Paget der Wirbelsäule. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1929, *40*, 999–1017.
11. KASABACH, H. H., and DYKE, C. G. Osteoporosis circumscripta of the skull as a form of osteitis deformans. AM. J. ROENTGENOL. & RAD. THERAPY, 1932, *28*, 192–203.
12. KAY, H. D. Plasma phosphatase in osteitis deformans and in other diseases of bone. *Brit. J. Exper. Path.*, 1929, *10*, 253–256.

13. Le Fort, R., and Moreau, J. L'ostéoporose circonscrite du crâne. *Arch. franco-belges de chir.*, 1934, *24*, 7–21.
14. Merkel, F. Handbuch der topographischen Anatomie. 1885–1890, *1*, 35.
15. Meyer-Borstel, H. Die zirkumskripte Osteoporose des Schädels als Frühsymptom der Pagetschen Knochenerkrankung. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1930, *42*, 589–596.
16. Moore, S. Observations on osteitis deformans. Am. J. Roentgenol. & Rad. Therapy, 1923, *10*, 507–518.
17. Palmer, H. D., Harrow, R., and Schwartz, L. A. Osteitis fibrosa cystica of the skull associated with hemianopsia and psychotic symptoms. *Arch. Neurol. & Psychiat.*, 1932, *27*, 45–57.
18. Pendergrass, E. P., and de Lorimier, A. A. Osteolytic lesions involving the calvarium. Am. J. Roentgenol. & Rad. Therapy, 1936, *35*, 9–29.
19. Pines, B. Ueber die porotische Pagetform am Schädeldach. *Virchow's Arch. f. path. Anat.*, 1933, *287*, 714–763.
20. Schellenberg, W. Osteoporosis circumscripta des Schädels. *Frankfurt. Ztschr. f. Path.*, 1931, *41*, 423–430.
21. Schmorl, G. Zur Kenntnis der Ostitis deformans Paget. *Verhandl. d. deutsch. path. Gesellsch.*, 1930, *25*, 205–214.
22. Schmorl, G. Ueber Ostitis deformans Paget. *Virchow's Arch. f. path. Anat.*, 1932, *283*, 694–751.
23. Schüller, A. Dysostosis hypophysaria. *Brit. J. Radiol.*, 1926, *31*, 156–158.
24. Schüller, A. Ueber circumscripte Osteoporose des Schädels. *Med. Klin.*, 1929, *25*, 631–632.
25. Schueller, A. Osteoporosis circunscripta del cráneo. Aspectos en la autopsia. *Rev. oto-neuro-oftal.*, 1932, *7*, 463–469.
26. Sosman, M. C. Radiology as an aid in the diagnosis of skull and intracranial lesions. *Radiology*, 1927, *9*, 396–404.
27. Sosman, M. C. Xanthomatosis (Schüller-Christian's disease; lipoid histiocytosis). *J. Am. M. Ass.*, 1932, *98*, 110–117.
28. Strandgaard, H. Nephrolithiasis associated with generalized osteitis fibrosa and hyperparathyroidism. *Hospitalstid.*, 1934, *77*, 383–393.
29. Vilaça, C. M., and de Almeida Toledo, P. Moléstia de Paget. Osteoporose circunscrita de Schüller. *Rev. Assoc. paulista de med.*, 1934, *4*, 13–19.
30. Weiss, K. Die Osteoporosis circumscripta Schüller, eine seltene, aber typische Erscheinungsform der Pagetschen Knochenerkrankung. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1930, *41*, 8–16.
31. Weiss, K. Die Osteoporosis circumscripta Schüller, eine seltene, aber typische Erscheinungsform der Pagetschen Knochenerkrankung. II. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1930, *42*, 376–378.
32. Whipple, A. O., and Frantz, V. K. Adenoma of islet cells with hyperinsulinism; a review. *Ann. Surg.*, 1935, *101*, 1299–1335.
33. Whitlock, S. B. Skull pathology revealed by the roentgen ray. *Radiology*, 1927, *9*, 153–161.
34. Zaccaria, A. Risultato della roentgenterapia in una oscura lesione della teca cranica, diagnosticata come osteoporosi circumscripta di Schüller. *Radiol. med.*, 1932, *19*, 857–864.

DISCUSSION

Dr. Sherwood Moore, St. Louis, Mo. I wish to congratulate Dr. Kasabach on his excellent paper. The report is such a complete study of the subject that there is virtually nothing left to be said. Paget's disease of the bone is probably a general disorder, in which at the present time we know only of bone changes. In some way the bone is so affected that it loses calcium. When bone weakens it attempts to repair itself, and it is the repair process in the bone of Paget's disease which is roentgenographically characteristic of the disease.

I am not familiar with Schmorl's work on hemorrhagic infarction of the cranium. It does not seem that osteoporosis circumscripta can be considered as the result of an infarct of the calvaria. It seems that if there were an infarct of the skull, there would be a massive necrosis of the skull with the sequelae which would be anticipated under such circumstances.

The question of osteoporosis circumscripta being obligatory in the development of Paget's disease of the skull needs some discussion. Paget's disease of the bone, as described by Paget in one of his papers, consists of two stages, and I believe his description will still stand—the first stage in which there is rarefaction and demineralization of the bone, and the secondary stage which is one of repair. Observation of the extension of Paget's disease in a long bone, for example, a tibia, will reveal a progressive rarefying process being followed by one in which there is the typical cotton-wool appearance with which you are all familiar. This sequence of events is very apparent in long bones, and I believe that it also takes place in the bones of the skull. It must be remembered, however, that repair processes in long bones and in membranous bones are not

identical. Repair of trauma or disease of the skull differs both from that in other cancellous bone and quite distinctly from that in long bones.

It seems to me that osteoporosis circumscripta is Paget's disease in which the preliminary stage of rarefaction is not followed by the usual course of repair. Why this should be the case in a limited number of cases of Paget's disease and not in the others is an enigma. In the writer's material 2 examples of osteoporosis circumscripta were found in 90 examples of Paget's disease, and in 1 case in which the other bones were not roentgenographed.

The case that I reported in 1923, to which Dr. Kasabach very kindly refers, was an example of osteoporosis circumscripta, but at that time, the condition had not been described, so the true nature of the case was not recognized. The patient showed obvious Paget's disease in the sacrum, ilium, and tibia.

In his paper Dr. Kasabach refers to the condition of the superior maxilla, and leaves one under the impression that he believes it to be neoplastic. The change in the superior maxilla in my case was a uniform, even hypertrophy, and I believe it was a simple increase in volume of the bone, which is one of the most important features of Paget's disease.

In this connection, the work of Dr. Robert Abbe, of New York, should be recalled. He has described Paget's disease in the superior maxilla and its treatment.

In his paper Dr. Kasabach says something about osteogenic sarcoma developing in Paget's disease. That is very frequently noted, and the deduction is that the Paget's disease is an etiological factor in the development of osteogenic sarcoma. In my material there has been 1 case of osteogenic sarcoma in 90 cases of Paget's disease. There was no case of Paget's disease in 39 cases of osteogenic sarcoma. A point, which is of importance to roentgenologists, is that fortunately all sarcomas are rather rare, and osteogenic sarcoma is far from common.

Dr. Merrill C. Sosman, Boston. We have been very interested in osteoporosis circumscripta for several years, and I thought I might trace very briefly the development of our knowledge of this peculiar lesion. As I remember, it was first described by Schüller and given the name of "osteoporosis circumscripta." The second paper was read by him at the International Congress in London when he differentiated this disease from xanthomatosis, which it is frequently called, but was unable to determine its etiology or its mode of progression or its eventual ending.

In 1924 we had a very marked case at the Peter Bent Brigham Hospital and Dr. Harvey Cushing did a biopsy on the involved bone in that patient, and, to my great surprise, our pathologist, Professor Wolbach, reported that histologically the tissue was perfectly characteristic of Paget's disease. We had many arguments pro and con on that point as to whether it was or was not Paget's disease, until we finally conceived the idea that, Paget's disease being two separate phases (one phase the absorptive phase as Dr. Moore has brought out—"demineralization"—the other phase being the productive phase), this might be the first phase alone; in other words, the absorptive phase of Paget's disease, and we coined the term "monophasic Paget's" to cover this osteoporosis circumscripta.

The next step in our acquisition of knowledge came several years later when we found this osteoporosis circumscripta in the skull of a patient who had Paget's disease in his pelvis, lumbar spine and tibiae.

The final stage was reported by Dr. Kasabach and Dr. Dyke, when they showed a transition in the same patient from this osteoporosis circumscripta lesion to the typical cotton-wool appearance of Paget's disease over a period of ten to fifteen years.

The cases we have seen showing this perfectly characteristic sharply demarcated outline and distribution are certainly evidence against any systemic theory as the sole cause of Paget's disease. It is hard to conceive of a disturbed carbohydrate metabolism, an endocrine imbalance, or any such systemic lesion causing such a localized abnormality, such very distinct edges and so slowly progressive as this lesion. They do add very definite weight to the theory that Paget's disease is after all primarily a disease of the arteries. It may be a lack of nutrition in the involved bone, and the most important addition to that theory is the recent article of Schmorl showing that this bone for all practical purposes is a hemorrhagic infarct, adding, I think, very strong weight to the idea that Paget's disease is a localized disease of bone, primarily depending upon endarteritis and not upon any systemic disease.

I was satisfied with the idea that it was a

localized endarteritis until just last week when one of the doctors in Boston showed me the roentgenograms of a patient with osteoporosis circumscripta, whom he had been following for years. The patient was a doctor. The process gradually advanced and did not bother him very much. He hadn't taken the time to have his metabolism and phosphorus balance and so on done, and not until it began to give him headaches did he consider any treatment. His doctor who was taking care of him, reading of the work in Detroit, thought that he might influence this disease by treating the parathyroid area with roentgen rays, which he did, a purely empirical treatment, a good clinical guess, and to my great surprise the area is receding very definitely. Instead of slowly advancing it is regressing. Part of the area formerly involved is now perfectly normal bone and it is improving very markedly.

I should like to present that to Dr. Kasabach and Dr. Dyke and Dr. Golden for their consideration, and ask them to try it in the cases that they have at present under control to see if they can obtain that very marked improvement. It may have been simply a coincidence.

On the final point that Dr. Sherwood Moore raised as to the development of sarcoma in Paget's disease, I again must disagree with my esteemed and distinguished colleague, and refer to a report which was made from our institution eight or ten years ago.* We had a hard working, conscientious resident who investigated the case records of 1,200,000 patients, including all of the patients registered in the Massachusetts General Hospital, the City Hospital, the Brigham and the Collis P. Huntington Hospitals. Out of that entire group he collected a large number of cases of Paget's disease and by a careful follow-up through several hospitals he arrived at the very definite finding that 8 to 11 per cent of the cases of Paget's disease died of osteogenic sarcoma. From my personal observation I would say that osteogenic sarcoma is not found in persons over fifty years of age unless they have Paget's disease. If you see a man over fifty with osteogenic sarcoma you can be almost sure that man has Paget's disease and that the sarcoma started in the Paget's disease.

* Bird, C. E. Sarcoma complicating Paget's disease of bone. *Arch. Surg.*, 1927, *14*, 1187–1208.

DR. KASABACH (closing). I thank Dr. Moore and Dr. Sosman for bringing up several interesting points in connection with this subject.

In a study of 116 cases of Paget's disease at the Presbyterian Hospital, we were led to concur with the generally accepted view that Paget's disease is not due to disturbed parathyroid function. Although our observations do not indicate any relation between the parathyroid glands and osteoporosis circumscripta of the skull, successful irradiation of the parathyroid glands in the case mentioned by Dr. Sosman suggests further trial of that form of therapy.

It is not possible to distinguish between Paget's disease and hyperparathyroidism solely by determining serum phosphatase activity, since high values are observed in both conditions. In hyperparathyroidism, however, values rarely exceed 45 Bodansky units per 100 c.c. In advanced Paget's disease, on the other hand, higher values (reaching 100 or more Bodansky units) are frequently observed.

Dr. Sosman's remarks on the incidence of sarcoma in Paget's disease are of great interest. In our series of 116 cases, sarcoma was present in only one patient. A second case of Paget's disease with osteoporosis circumscripta of the skull, included in the present paper, developed sarcoma arising from the area of osteoporosis circumscripta in the skull. We ascribe the low incidence of sarcoma in our series of cases to the fact that our group included many relatively early cases.

The number of reported cases of osteoporosis circumscripta of the skull has increased in the last two or three years, but chiefly in the continental literature. We hope that further studies will be made since the condition is of interest not only for itself but because of the possible light it might throw upon the pathogenesis of Paget's disease.

Vol. 37, No. 5

ROENTGEN EVIDENCE OF THE BEHAVIOR OF THE HUMAN LUNG IN RECENT TUBERCULOUS INFECTIONS*

By KENNETH D. A. ALLEN, M.D.
DENVER, COLORADO

SERIAL roentgen examination of the lungs of children and adults furnishes certain definite evidence concerning the behavior of tuberculous infection. It is the purpose of this paper to consider that evidence.

Numerous experiments on guinea pigs and rabbits quite conclusively show that virulent tubercle bacilli are carried away from the original site of deposit in the body much more quickly in those animals not previously infected (non-allergic) by the *Mycobacterium tuberculosis* than in those previously infected (allergic animals).[2,3,7,8,9,14] Certain students of tuberculosis have contended for many years that this is also true in man, especially of deposits in the lung parenchyma.[5]

More and more, internists and roentgenologists are accepting these earlier concepts, namely that tubercle bacilli deposited in the lung parenchyma in certain doses, in the non-allergic individual, travel to the hilar lymph nodes where their first roentgen manifestation (if any) takes place. They are also inclined to agree that regardless of the dose, bacilli deposited in the lung parenchyma of the allergic (previously infected) patient remain fixed where deposited and there produce their effect, little or no involvement accruing at the hilus. There are still too few radiologists, however, whose roentgen interpretation of pulmonary tuberculosis is based on these concepts.

Evidence of the accuracy of the foregoing tenets in man is not as conclusive as in animals because necropsy material of *early* stages of tuberculous infection is relatively scarce. Such material is especially difficult to obtain in the *early second* infection type.

It is not difficult to understand the rapid and facile lymphatic drainage to the hilar nodes of a certain dose of tubercle bacilli when there is no allergic inflammation to obstruct the lymphatics and to fix[7,11] the bacilli to the host tissues. Neither does it seem extraordinary that long-standing, destructive second infection lesions of the parenchyma should block most of the drainage to the hilar region and thus prevent gross lung root involvement; but it is surprising to observe that even extremely early minimal second infection not only fails to reach the hilus but often remains in the parenchyma, displaying, roentgenologically, new areas of progressive infection. Sometimes for months and years there are exhibited very small lesions only, but unhealed and steadfastly remaining in the lung periphery (Fig. 4).

If, by serial roentgenography, we could follow all cases of first infection which show masses of uncalcified lymph nodes at the hilar region, doubtless many, in months or years, would develop a calcified Ghon focus in the parenchyma which would mark the point of original deposit, despite the fact that during the active stage of node enlargement no parenchymal lesion could be depicted (Figs. 1 and 2). Conversely, those patients in whom the Ghon nodule is found, might have shown enlarged uncalcified hilar lymph nodes during the active stage[13] (Fig. 3). Also, properly made roentgenograms of the active stage would doubtless have shown uncalcified nodes projecting into the lung fields in many of the cases which subsequently are found to possess *calcified* hilar lymph nodes.*[12]

* Slightly oblique views in addition to the routine postero-anterior and lateral will visualize smaller masses than can otherwise be seen.

* Read at the Thirty-seventh Annual Meeting, American Roentgen Ray Society, Cleveland, Ohio, Sept. 29–Oct. 2, 1936.

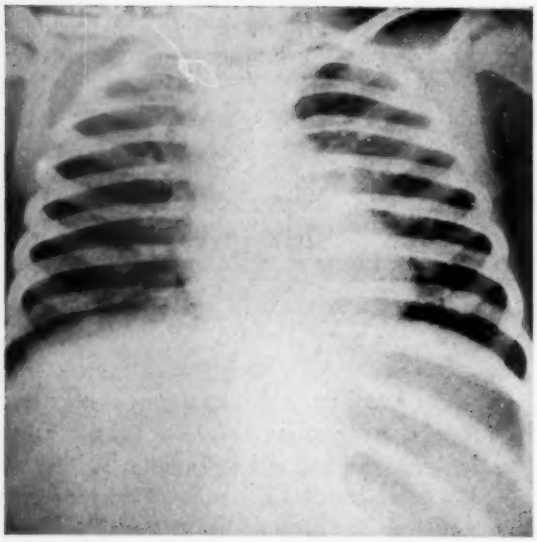


Fig. 1*a*.* First infection tuberculosis in a girl, aged fifteen months. Note the enlarged left hilar lymph nodes partially hidden by the left border of the heart. The parenchymal deposit area of the infection has not yet become visible. See Figure 1*b*.

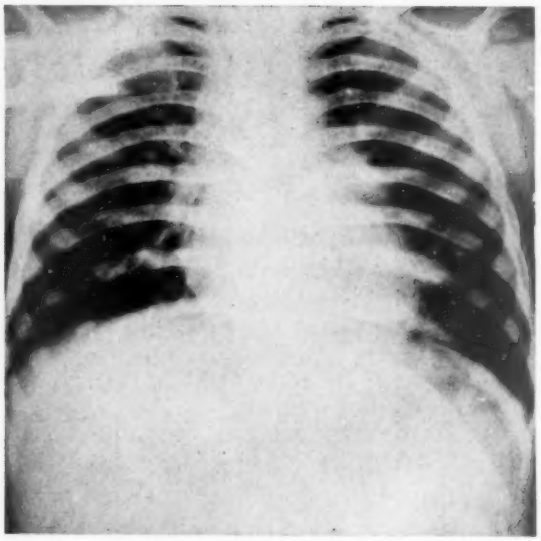


Fig. 1*b*. The same patient as shown in Figure 1*a* is now seventeen months old. The left hilar shadow has subsided a little. There is still no visible parenchymal lesion. See Figure 1*c*.

Fig. 1*c*. The patient shown in Figures 1*a* and 1*b* is now thirty-five months old. The left hilar shadow is about normal. The parenchymal deposit area is becoming visualized under the posterior portion of the seventh rib about 4 inches from the spine. See Figure 1*d*.

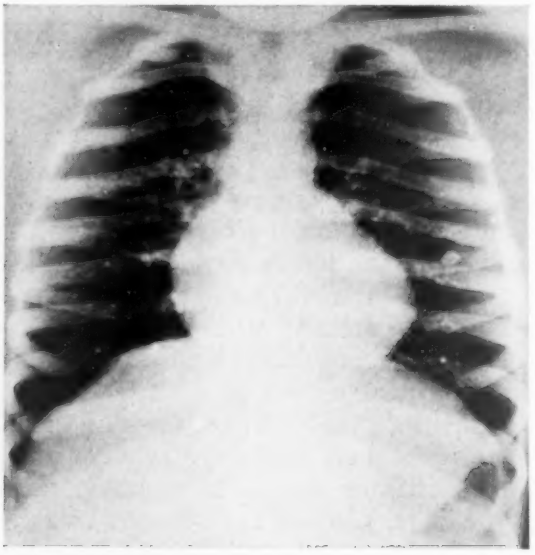


Fig. 1*d*. The patient is now six years old. The Ghon deposit area is clearly demonstrated. It seems that in first infection in moderate dosage the bacilli travel to the hilus and tracheobronchial lymph nodes. The proliferative parenchymal lesion only becomes visible if it calcifies or if the patient is subjected to huge or repeated dosage. See text.

A case in point is one of typical first infection tuberculosis. Serial roentgen examinations (Figs. 1*a*, *b*, *c*, *d*) show, in the earliest roentgenograms, enlargement of the left hilar shadow, presumably due to

* These serial roentgenograms were made at the Children's Hospital and at Child Research Council, Denver, Colorado.

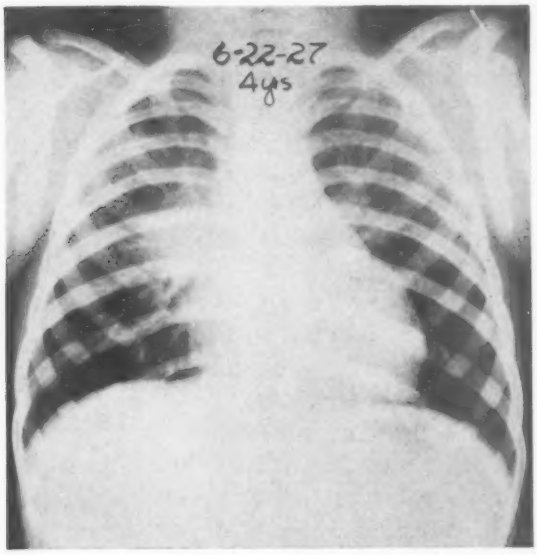


Fig. 2*a*. The intensification of the right hilus is presumably the result of first infection tuberculosis which has traveled from a parenchymal deposit area. Careful scrutiny suggests a small lesion behind the posterior portion of the fifth rib about 3 inches from the spine. It is visualized at this stage only because of repeated dosage.

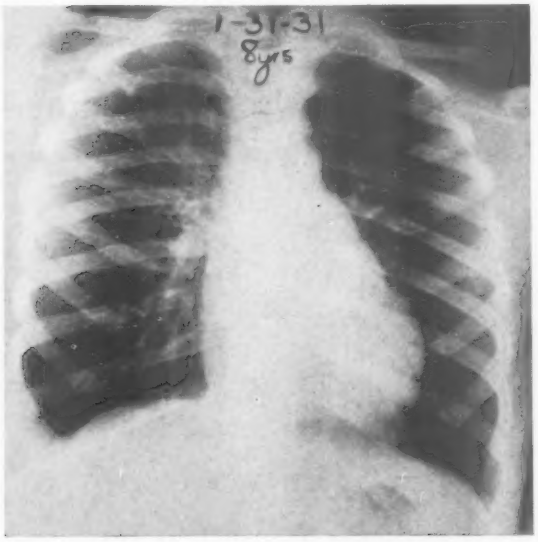


Fig. 2*c*. The same patient as in Figures 2*a* and 2*b*. The Ghon focus is quite plainly seen at this time See Figure 2*d*.

caseous lymph nodes. The persistence of this shadow for several months is strong evidence against other etiological causes. Later developments confirm this opinion.

Fig. 2*b*. The same patient as in Figure 2*a*. The right hilar shadow has subsided. The parenchymal lesion in the right upper lobe is more plainly visible. See Figure 2*c*.

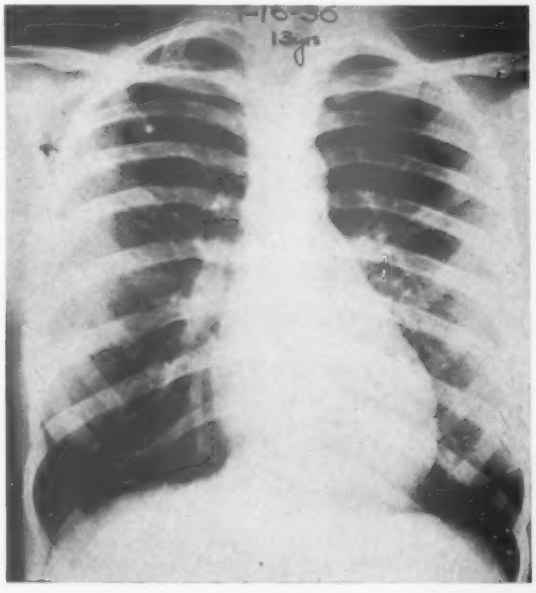


Fig. 2*d*.* A recent serial roentgenogram showing the Ghon focus and almost normal right hilar shadow. See legend for Figure 1*d*.

The later serial roentgenograms reveal the subsidence of the intensified hilar shadow, and careful scrutiny soon discloses the

* The serial studies were made at the Child Research Council, University of Colorado School of Medicine.

Fig. 3. Tuberculous right tracheobronchial lymph nodes. A typical roentgen sign of first infection. The parenchymal deposit area is invisible at this stage. See text.

beginning visualization of a Ghon focus in the left lower lobe which becomes very plain in the last roentgenogram which also depicts minute calcifications in the hilus.

Another similar patient shown in Figures 2*a*, *b*, *c*, *d*, is a four year old child. There can be noted marked enlargement of the right hilar shadow probably due to enlarged lymph nodes surrounded by a fleeting benign consolidation (epituberculosis). Only the faintest parenchymal lesion can be identified at this time. As the hilar density subsides the parenchymal lesion begins to show in the right upper lobe. In the latest roentgenogram a Ghon tubercle is plainly visible.

These patients and another shown in Figure 3 present strong evidence that in first infection tuberculosis the deposit area is in the parenchyma, producing only a minute proliferative lesion, and that the infection travels quickly to the hilar region. These patients have probably suffered from moderate dosage only.[1] Repeated or large doses produce different roentgen signs, the description of which is not pertinent (Fig. 2*a*).

It is generally conceded that nodular lung calcifications are practically always the result of tuberculous infection. Now if two pulmonary areas of tuberculosis begin to calcify at about the same time in the same patient, as was particularly evident in Case 1, it can be suspected that the etiological organism arrived in both places at about the same time. Since it is difficult

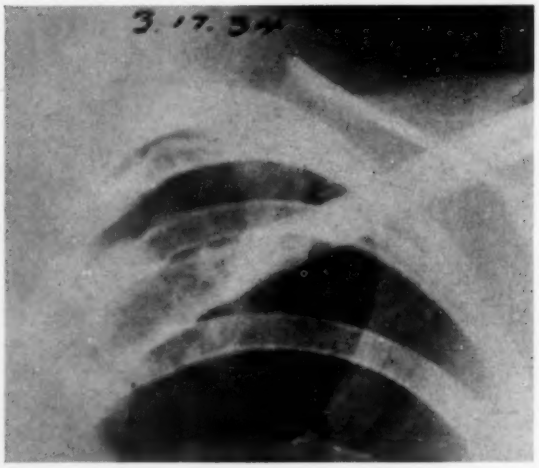


Fig. 4*a*. The fuzzy haziness in this left apex strengthens greatly a clinical diagnosis of tuberculosis. The infiltration "stereoscopes" into the lung tissue. No sign of hilar involvement accompanies this apical lesion. See Figure 4*b*.

Fig. 4*b*. The same patient as shown in Figure 4*a*. After proper treatment the fuzzy haziness has subsided. The margins of the lesion are more discrete. Definite roentgen evidence of improvement. The full roentgenogram still discloses no hilar involvement. See Figure 4*c*.

to assume that tubercle bacilli can reach the lung root other than by lymph drainage from the lung parenchyma, the patients shown in Figures 1, 2 and 3 furnish evidence that in the non-allergic the first infection travels promptly along the lymphatics to the hilar region.[6,10]

Figures 4 and 5 depict the behavior of tuberculous infection *after* the tissues have become allergic from a previous first infection. They present evidence by serial roentgenograms that mild or severe disease remains in the lung parenchyma instead of passing to the hilus and tracheobronchial lymph nodes as it does in the patients infected for the first time. The 2 patients whose roentgen studies are about to be described are both clinically proved to be cases of the adult type of pulmonary tuberculosis. One serial study begins before the advent of the reinfection; the other probably shortly afterward.

Fig. 4*c*. The patient returns to duty as a nurse. Fresh infiltration and exudate have appeared adjacent to the region of the old lesion which has almost disappeared. See Figure 4*d*.

Fig. 4*d*. The discrete margins, contraction and increased density evidence improvement in the apical adult type tuberculous lesion of the left apex of the patient depicted in Figures 4*a*, *b* and *c*. See Figure 4*e*.

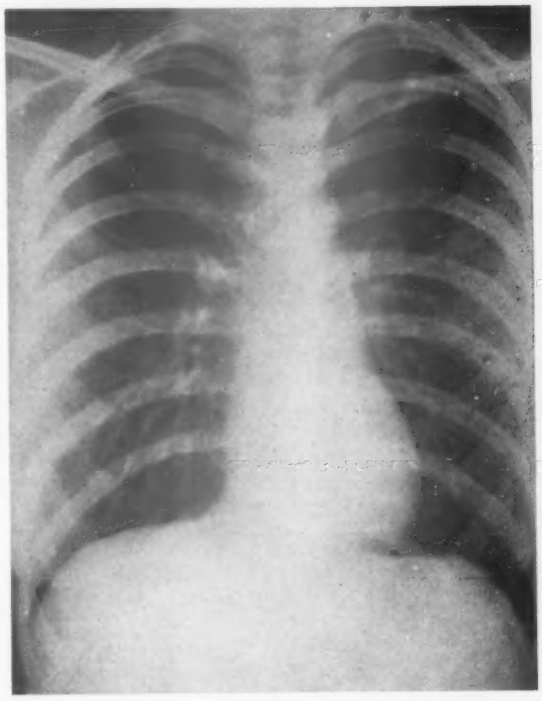


Fig. 4*e*. After more than two years the left apical reinfection tuberculosis assumes the roentgen characteristics of healing. Even this minimal amount of infection failed to produce roentgen evidence of hilar involvement. Contrast this case with the behavior of *first* infection shown in Figures 1 and 2.

The five serial roentgen examinations shown in Figures 4 *a*, *b*, *c* and *d*, are those of a nineteen year old student nurse. They cover a period of twenty-five months. The first roentgenogram evidences a parenchymal exudate in the left apex which stereoscopes into the lung tissue. After four months' rest in bed, combined with what seemed to be the proper, though slight, amount of exercise, rapid improvement ensued. Much of the exudate appears to have resolved, some fibrous tissue is present and the lesion is smaller, irregular and more discrete. Against advice the patient soon returned to duty. The third

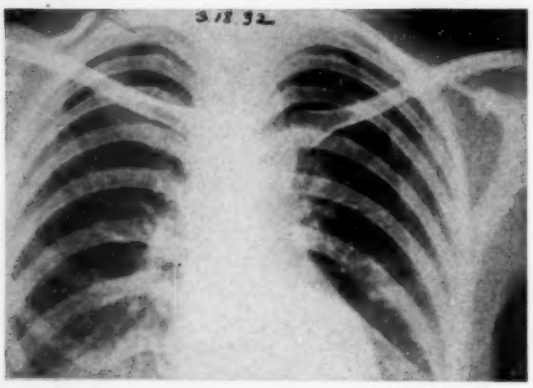


FIG. 5*a*. Calcifications in left upper lobe and hilus suggest old first infection tuberculosis. No second infection type is yet present. See Figure 5*b*.

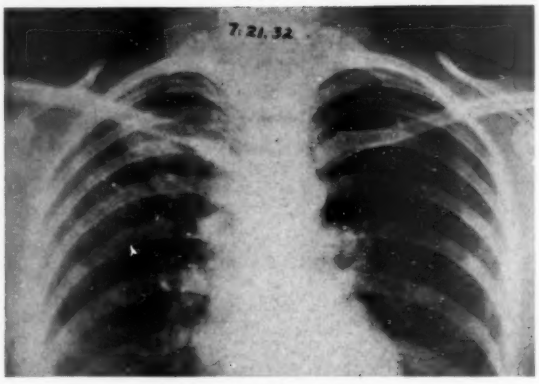


FIG. 5*b*. Only four months after Figure 5*a*. There is abundant evidence of reinfection type tuberculosis. In the following serial roentgenograms (Figs. 5*c* and 5*d*) note how steadfastly the disease remains in the parenchyma, whereas the left-sided first infection involved the hilus.

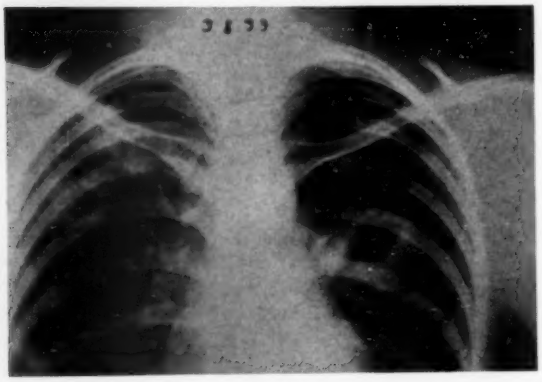


FIG. 5*c*. While the right lung is improving, a fresh involvement has developed in the posterior portion of the left lung behind and peripheral to the hilus. The enlargement of the left hilus is only apparent due to rotation of the patient. See Figure 5*d*.

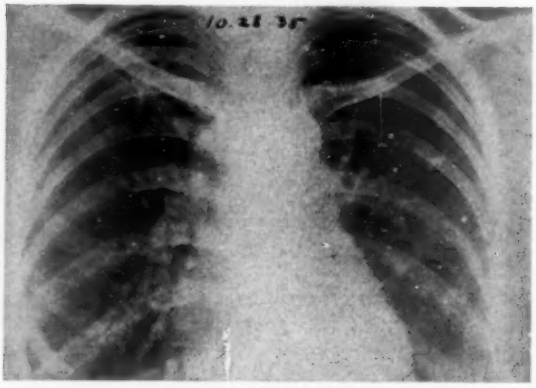


FIG. 5*d*. The second infection has now markedly subsided. Throughout its entire course it remained in the parenchyma.

serial roentgenogram made after six months of nursing duty, depicts a new area of fuzzy haziness adjacent to the old lesion. The two lesions of different densities are almost pathognomonic of second infection tuberculosis; a succession of chronic infections.[4] Proper treatment was again followed by some absorption of the exudative infiltration, increased discreteness of the lesion and contraction of the involved lung tissue. The last roentgenogram reveals no recent hilar involvement and no intensified trunk shadows leading to the hilar region. Even this minimal amount of involvement throughout a period of over two years seemed unable to drain to the hilus.

Figure 5 presents additional evidence that a second infection pulmonary lesion is confined to the parenchyma. It is a serial study of a young woman aged twenty-four. The first roentgen examination shows a Ghon tubercle in the left apex and vague calcification at the left hilus which denotes healed first infection tuberculosis. This is corroborated by a positive skin test. No adult type of tuberculosis is yet present. Subsequent roentgenograms disclose many areas of exudation and infiltration in the right upper lobe. As the disease in the right upper lobe subsides, fresh exudation and infiltration occur in the left lung at the level of the

posterior portion of the seventh and eighth ribs. While healing is taking place in the right lung, a new lesion is developing in the left lung. Finally, there is marked improvement throughout, which led to apparent complete arrest. During more than two years the second infection remained constantly in the lung parenchyma without demonstrable hilar involvement.

Had we serial lung roentgenograms made from infancy to adult life on more cases of tuberculosis, much could be learned concerning the physiologic pathology of tuberculous infection. The accumulation of serial studies points more and more clearly to the long reported, but too little used concept, that first infection tuberculosis of the lungs quickly reaches the lung root nodes. Moderate doses seem to produce a minimal effect in the lung parenchyma, whereas infection deposited after the first infection has subsided or healed remains in the peripheral lung tissues. This roentgen evidence concerning tuberculosis in man conforms to the behavior of tuberculous infection in experimental animals.

SUMMARY

(1) Abundant animal experimentation shows that virulent tubercle bacilli are quickly carried away from the original point of deposit in animals not previously infected by the *Mycobacterium tuberculosis*. It further indicates that there is a tendency for the bacilli to remain in the deposit area in animals previously infected.

(2) Serial roentgen examinations of the lungs of human patients support the conception that the same tissue behavior obtains in man as in animals.

(3) Necropsy material permitting a study of *early* first or second infection tuberculosis is scarce. Roentgen examination carried out serially over long periods of time contributes considerable evidence concerning the behavior of tuberculous infection of the lung. Several cases are presented.

REFERENCES

1. Allen, K. D. A. The present status of x-ray interpretation of pulmonary tuberculosis in children. *Colorado Med.*, 1935, *32*, 530–540. Also, *Northwest Med.*, 1935, *34*, 238–245.
2. Burke, H. E. A comparison of the roentgenological and the pathological findings in experimental pulmonary tuberculosis in rabbits. 1. Primary tuberculosis. *Am. Rev. Tuberc.*, 1935, *32*, 343–381.
3. Burke, H. E. A comparison of the roentgenological and the pathological findings in experimental pulmonary tuberculosis in rabbits. 2. Reinfection tuberculosis. *Am. Rev. Tuberc.*, 1935, *32*, 382–423.
4. Dunham, K. The clinical value of the chest radiogram. *Tubercle*, 1935, *17*, 33–38.
5. Dunham, K., and Skavlem, J. H. Applied pathology of pulmonary tuberculosis. *Radiology*, 1925, *4*, 181–187.
6. Krause, A. K. The spread of tuberculous infection in the body. *Am. Rev. Tuberc.*, 1924, *9*, 83–96.
7. Krause, A. K. Studies in tuberculous infection. XII. The dissemination of tubercle bacilli in the immune guinea-pig, with a discussion of probable factors involved in tuberculo-immunity. *Am. Rev. Tuberc.*, 1926, *14*, 211–236.
8. Krause, A. K. Anatomical structure of the tubercle from histogenesis to cavity. *Am. Rev. Tuberc.*, 1927, *15*, 137–168.
9. Krause, A. K., and Willis, H. S. Rate of dissemination of virulent tubercle bacilli in normal and immune guinea-pigs. *Tubercle*, 1925, *6*, 438–443.
10. Miller, W. S. Studies on tuberculous infection. III. The lymphatics and the lymph flow in the human lung. *Am. Rev. Tuberc.*, 1919–1920, *3*, 193–209.
11. Opie, E. L. Fate of antigen (protein) in an animal immunized against it. *J. Exper. Med.*, 1924, *39*, 659–675.
12. Opie, E. L. Significance of advanced tuberculous infection of school children. *J. Am. M. Ass.*, 1930, *95*, 1151–1158.
13. Opie, E. L., and Andersen, H. First infection with tuberculosis by way of the lungs. *Am. Rev. Tuberc.*, 1920–1921, *4*, 629–639.
14. Rich, A. R., and McCordock, H. A. Enquiry concerning the rôle of allergy, immunity and other factors of importance in the pathogenesis of human tuberculosis. *Bull. Johns Hopkins Hosp.*, 1929, *44*, 273–422.

DISCUSSION

DR. KENNON DUNHAM, Cincinnati, Ohio. Dr. Allen's presentation of this intriguing subject challenges our admiration. It must be remembered that here we are dealing with subjects such as allergy, immunity, hypersensitiveness, primary infections of tuberculosis, benign tuberculosis and epituberculosis all considered from a roentgen film. Do we understand the meaning of this terminology? Possibly as individuals you have understanding, but I have found no two authorities who have the same understanding of these terms. The author has dealt ably with these terms and has given us his understanding and discussed them with relation to roentgen lung densities. I find this presentation good and have no criticisms of the interpretations.

It is rather my purpose to call your attention to the fact that it is an able presentation for your study and consideration rather than a final answer to the subjects involved. Allergy, as referred to tuberculosis, is a change in the body brought about by infection with the tubercle bacilli, as are immunity and hypersensitiveness to tuberculosis, but they are not the same thing nor can they be measured by the tuberculin reaction. Also benign tuberculosis and epituberculosis are terms so ill-defined that I believe they should not be used until we understand them better. I rather like to think of the reaction of the economy to tuberculosis in two stages, primary, that before allergy has been developed and inflammatory after allergy has fully developed.

Primary infections should never be thought of as the first infection. The reaction to these primary infections are not localized to the point of inoculation but drain to the lymph nodes, and if the infection is severe may result in generalized tuberculosis such as miliary tuberculosis. The second stage is when the reaction of the body to the bacillus is an inflammatory reaction. Great effort is made to localize the infection to the point of inoculation. This is after the so-called allergy has developed. Thus like all inflammatory reactions they may be severe or slight. But have we knowledge enough to say which is benign when we first examine the case or can we say definitely that this pulmonary exudate is due to tuberculosis? All that we have a right to deduce is that we have evidence of pulmonary exudate. Also when on single films we see a hazy density over the hilus, can we say that the density is in the hilus? It is often in the third upper of the lower lobe which overlies the hilus.

Certainly pulmonary exudate must be treated as tuberculosis until we prove it otherwise, but for scientific purposes and the benefit of our understanding I urge that we do not make a positive diagnosis on slight proof and opinion, and that we avoid using terms which are easily misunderstood.

The points which I am trying to make are illustrated by the modern trend to diagnose tuberculosis in children by a roentgen film and a tuberculin reaction. This is propounded from high authority. It is false. False because it misleads the profession and the laity. If these tests were as reliable as they are relied upon we should be able to determine which children can be safely left in school and for which children we should prescribe definite hours of bed rest. This we cannot do. Calcification in the bronchial lymph nodes and a positive tuberculin reaction indicates tuberculous infection, but whether immunity has developed and to what extent it has developed is undetermined.

The practical point to determine is whether there is positive sputum in the child's home. If there is, and has been for three months, we should care for that child as one seriously infected whether we find calcification or a positive tuberculin test is reported. Many such infected children do not show calcium nor give a positive reaction for some months after exposure. I have intentionally digressed a little from the original paper but do so because Dr. Allen has presented so fine a paper that I take the liberty to broaden the subject for your consideration.

DR. LEO G. RIGLER, Minneapolis, Minn. Dr. Allen and Dr. Dunham have opened up such a wide field that has been so thoroughly discussed by phthisiologists and pathologists, that it is difficult to refrain from entering into one or two phases of it.

I think perhaps it might be well to point out that studies of primary tuberculous infection in childhood with follow-up studies over a long period of time have been conducted at Lymanhurst in Minneapolis. While I am thoroughly critical of some of the conclusions which have

been drawn from that work, there are certain phases of it which cannot be gainsaid.

They have seen many children, picked up in the schools for no good reason at all except that they perhaps are a little bit under weight, or some such thing as that, but these have given the institution the opportunity of observing children at regular intervals over a period of almost fourteen years. Their impression and our impression is that the first lesion that is seen in childhood is an entirely different one from what we call reinfection tuberculosis—it acts in an entirely different way—but the primary lesion seen in the lung is a parenchymal one. The glandular enlargement is a constant and very characteristic phase of the condition, but appears, at least from our observations, to be a secondary rather than a primary lesion in the lung.

Another observation which they have made, and which I have had the opportunity of seeing, is concerned with this question of immunology in tuberculosis. A fair percentage at least of these children who develop parenchymal lesions have been followed over a period of time, during the course of which the lesion has become completely calcified and has reduced itself in size, the glands have become calcified and then superimposed on it a typical reinfection—adult tuberculosis—has occurred. The conclusion of the Lymanhurst investigators has been that the first infection does not confer immunity; that, in fact, the change in the character of the type of tuberculosis which occurs with reinfection, which is likely to produce cavitations and death, indicates that the first infection has rather been a harmful thing; it has, as Dr. Allen pointed out, produced a tissue allergy which has been distinctly harmful rather than beneficial.

That is a subject which could be discussed at great length, and I don't want to enter into it except to point out that these observations have been made over a long period of time.

One other thing has been of considerable interest to me and I think perhaps might well be emphasized. We have had the opportunity of studying medical students and nurses, and in a sense they almost form a group of laboratory animals because we have them under such close observation. Our medical students have had skin tuberculin tests done from the time of their entrance into the University during a period of about the last ten years, annually, sometimes semi-annually, and roentgenograms of the lungs made during this same period of time. We have collected a fair number of cases, I think about 12, on which we have very accurate figures.

Medical students who have a negative tuberculin reaction repeatedly and negative roentgenograms repeatedly, may then enter on a tuberculous service and get a very short exposure to tuberculosis, perhaps not longer than two weeks in many instances. Within ten days to two weeks a very high percentage of them develop a positive tuberculin reaction. That doesn't mean a great deal because only in a very small percentage of these do we ever find any evidences, at least on roentgen examination or clinically, of tuberculosis. We have found in a small number definite evidences of parenchymal tuberculosis following closely enough after this exposure and this change in the tuberculin reaction to make it reasonably certain that the two are closely related.

What interests me particularly is that these individuals with a negative skin allergy nevertheless develop lesions which are identical to what Dr. Allen has described as the characteristic reinfection type of tuberculosis. They don't look like what we expect to find in the childhood type.

I might say, parenthetically, that in the course of this study we have been able to demonstrate, at least to the satisfaction of some of us, that it is possible to diagnose pulmonary tuberculosis in the roentgenogram on an adult within about eleven to twelve weeks after the first exposure to the tuberculosis, and in a much shorter time, somewhere in the neighborhood of eight or nine weeks, after the skin reaction first becomes definitely positive.

Dr. Allen (closing). I should like to answer Dr. Rigler's discussion before I thank Dr. Dunham for his discussion. I believe that the first deposit of tubercle bacilli in first infection, or childhood type tuberculosis, is in the parenchyma, but often not roentgenologically manifested.

That which varies the roentgen manifestation of first infection tuberculosis is first, the size of the dose; second, whether the dose is repeated or not. If the child receives a moderate dose of tubercle bacilli in the parenchyma of the lungs, and then the next day or the next week, or shortly after, gets another dose and

then another dose, enough allergy may be developed to present roentgenographically, an inflammatory reaction. In this event, there is parenchymal manifestation of the disease. I believe in the average case of moderate dosage without repetition there is no parenchymal manifestation.

As to the students who have developed reinfection manifestations, or adult type of tuberculosis with negative tuberculin reaction, there are two things to consider: first, does a positive tuberculin mean only a hypersensitivity to a foreign protein or is it pathognomonic of tuberculosis? This point has not been proved. Secondly, Dr. Rigler answered his own question by saying that the patient may not be hypersensitive to tuberculin in such a remote area as the skin but may have local tissue allergy in the lung, and, thus the newly deposited tubercle bacilli in the lung may cause a typical "reinfection" response because there is allergy there but not in the skin.

I wish to thank Dr. Dunham and Dr. Rigler for their excellent discussions.

Vol. 37, No. 5

DIAPHRAGMATIC HERNIA AND ASSOCIATED CONDITIONS

By J. H. MARKS, M.D.
FALL RIVER, MASSACHUSETTS

IN THE earlier medical literature the condition of diaphragmatic hernia was looked upon as an anatomical variation which was quite rare. The diagnosis was seldom made except at autopsy. In 1912 only 15 of the 650 cases collected by Giffin[12] had been diagnosed during life, and Pancoast and Boles[28] were able to find only 47 cases so diagnosed prior to 1923. During more recent years many reports of hernia through the diaphragm have appeared, and although the condition is not a common one, it has been shown to occur with sufficient frequency to demand the attention of every member of the medical profession. Unfortunately, the large number of papers which have appeared has not served to clarify the problem and there is no general agreement as to terminology or as to the etiological factors involved. Many authors have attempted to classify the various types of hernia and the associated conditions, but none of the classifications yet offered has proved entirely satisfactory and none has been widely accepted. In the present study a classification which includes the best features of those previously published has been employed. This grouping is based upon the evidence which can be obtained by the roentgenologist, and it is my belief that it is of value in arriving at the proper course of treatment for the individual case.

The study of the problem of diaphragmatic hernia and the recognition of the fact that it is not a rare condition has brought it to the attention of all who are concerned with the disorders of the gastrointestinal and respiratory systems. Both the internist and the surgeon have come to include it in their differential diagnosis, but the roentgenologist is the one on whom the major portion of the responsibility rests in making the diagnosis in most cases. It is quite proper, therefore, that the roentgenologist should have a very keen interest in this problem. If his examination is made with care and with a knowledge of the various types of hernia which may occur he may be of invaluable assistance in directing the proper course of treatment for the patient.

ANATOMY

A review of the anatomy of the diaphragm shows that it is comprised of three main parts, all of which insert into the central tendon. The pars sternalis arises from the xiphoid process. The pars costalis arises anteriorly and laterally from the costal cartilages of the six lower ribs. The pars lumbalis arises posteriorly from the crura and from the medial and lateral lumbocostal arches. The crura in turn arise from the bodies of the first three lumbar vertebrae. The medial lumbocostal arch is a fibrous band which extends from the body of the second lumbar vertebra to the transverse process of the first and thus bridges the psoas muscle. The lateral lumbocostal arch extends from the tip of the transverse process of the first lumbar vertebra to the twelfth rib and bridges the quadratus lumborum muscle. Failure of fusion of the pars costalis with the pars lumbalis results in a persistent hiatus pleuro-peritonealis or foramen of Bochdalek, and this is a common site of hernia in children. Similarly the foramen of Morgagni is formed if there is failure of fusion of the pars sternalis with the pars costalis. A sketch of the diaphragm as seen from above is shown in Figure 1.

It should be noted that there is no sharp line of demarcation between the normal and the abnormal as regards the fusion or failure of fusion of these several segments of the muscular portion of the diaphragm. Even in the normal adult there is often a triangular space which separates the muscle fibers of the posterior and lateral segments. This space is filled by a thin layer of connective tissue which is covered above and below by the pleura and peritoneum respectively. This thin layer of connective

tissue is much less elastic, and hence more easily torn, than the surrounding muscle and that it is not more frequently the site of hernia is probably due to the fact that the area is protected by the liver and by the fatty tissues surrounding the adrenal gland and the upper pole of the kidney. That the protection offered by the liver is a very real thing is shown by the fact that even in traumatic cases 95 per cent of the herniae occur on the left side.

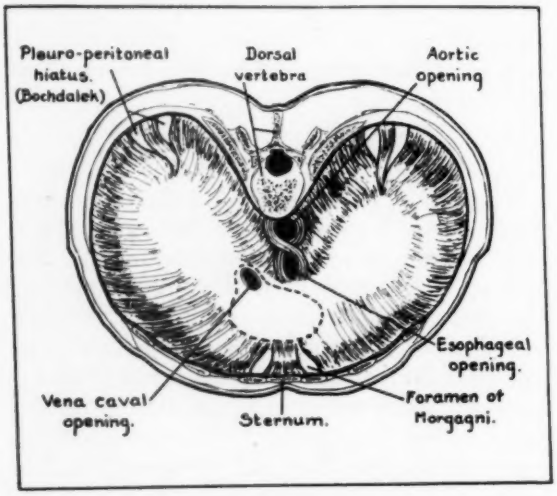


Fig. 1. The diaphragm as seen from above.

The formation of the diaphragm and the separation of the celomic cavity into the pleural, pericardial and peritoneal cavities is a complex process which begins in the human embryo when it is about 2.1 mm. in length. The division of the three cavities is not complete until the embryo is about 20 mm. in length. The muscle fibers between the pleural and peritoneal membranes come in even later and are of independent origin, being derived from the fourth cervical myotome. If displacement of a portion of the gut takes place before the division of the celomic cavity is complete the misplaced loops of bowel will not be covered by a serous membrane and the hernia will not be a "true" one. If the displacement occurs after the formation of the pleural and peritoneal cavities is complete but before the muscular elements have grown in or become properly fused, then the loops of gut will be covered by a serous sac and the condition will be a "true hernia."

Of the several openings in the diaphragm through which structures normally pass, that of the aorta is most posterior and is at the level of the first lumbar vertebra. This opening is not properly within the diaphragm but its anterior and anterolateral boundaries are formed by the crura of the diaphragm as they extend forward from their points of origin on the anterior aspect of the spine. The thoracic duct and the azygos vein pass through the same opening closely adjacent to the aorta. The opening is well bounded by dense fibrous tissue and no hernia has ever been reported passing through it. The esophageal opening is somewhat more anterior and is at the level of the tenth thoracic vertebra. Besides the esophagus it transmits the esophageal vessels and the vagus nerves. It is entirely within the muscular portion of the diaphragm, being surrounded by the decussating bundles of the crura just before they spread out and insert into the central tendon. There is considerable variation in the size of the esophageal opening and the space not occupied by the structures passing through it is filled by loose areolar tissue. Careful exploration of the upper abdomen in persons being operated upon for various conditions has shown that the opening may be small enough to admit only one finger snugly or it may be large enough to admit three or even four fingers. The opening for the vena cava occupies a still more anterior position and is situated at a still higher level, being opposite the disc between the eighth and ninth thoracic vertebrae. It is within the central tendon of the diaphragm and is just to the right of the midline. It is well protected by the liver and is not the site of hernia.

CLASSIFICATION

Of the various classifications already offered in the literature most are concerned primarily with two points of interest: first, whether the hernia is congenital, acquired or traumatic; and second, whether the hernia is true or false, that is, whether or not the displaced organs are enclosed within a serous sac. These points are of course of interest, but a knowledge of them is of little help in outlining a proper course of treatment for the patient. It has seemed to me that the information of most value would be that which would aid in determining whether or not the case at hand was amenable to surgical repair.

The internist or surgeon can frequently

make the diagnosis of hernia in a well-marked case of the congenital type or in a case with a clear-cut history of adequate trauma, and he may at least suspect the correct diagnosis in cases of the hiatus type. The roentgenologist must verify the diagnosis in cases of the congenital or traumatic type and can make a preoperative diagnosis of just which organs are involved. In patients suspected of having hiatus hernia, the roentgenologist must determine whether or not a hernia is actually present and he must also determine whether or not the esophagus is of normal length. He must at all times differentiate between hernia through the diaphragm and eventration of the diaphragm.

During the past two and a half years I have examined a total of 29 cases of diaphragmatic hernia and associated conditions. Of these, 2 were of the type with a short esophagus, 2 were of traumatic origin, 1 had eventration of the left diaphragm, 6 were of congenital origin seen in children and 17 were of the hiatus type. No cases of thoracic stomach or of congenital absence of the diaphragm were seen.

The classification which we have used is as follows:

1. Thoracic stomach.
   Entire stomach above the diaphragm.
   Esophagus very short.
2. Diaphragmatic hernia with short esophagus.
   Part of stomach above the diaphragm.
   Esophagus ending at 7th or 8th thoracic vertebra.
3. Hiatus hernia.
   Hernia through the hiatus oesophageus.
   Esophagus of normal length.
4. Congenital hernia.
   Most common through the foramen of Bochdalek of Morgagni. Large and small bowel usually included; other organs frequently.
5. Traumatic hernia.
6. Eventration of the diaphragm.
7. Congenital absence of the diaphragm.

1. Thoracic Stomach. The term thoracic stomach was well given by Bailey[2] to a case described by him in 1919. The group of cases having all of the findings described by Bailey is a very small one but much confusion would be avoided if the term were used only to describe this group. It is unfortunate that the literature contains many reports of "thoracic stomach" which upon closer examination prove to be nothing more than the very common type of hiatus hernia in which a relatively large portion of the stomach has been found above the diaphragm. The true thoracic stomach is an anatomical variant which cannot be corrected by any surgical procedure, whereas the hiatus hernia is an acquired lesion which may be repaired if the symptoms warrant.

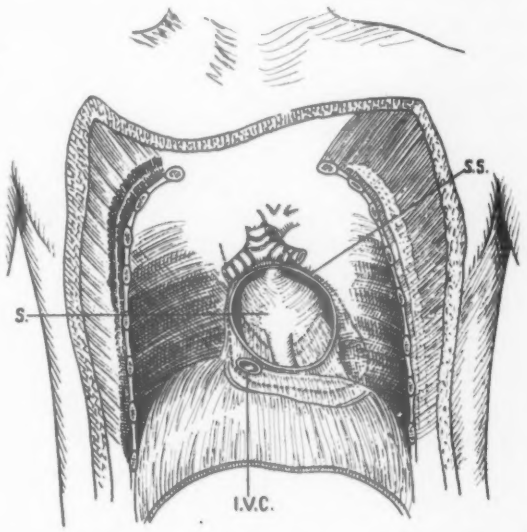


FIG. 2. Bailey's case of thoracic stomach. Lungs and heart removed and serous sac surrounding the stomach opened. *S*, stomach; *S.S.*, serous sac around stomach; *I.V.C.*, inferior vena cava.

In the cases of true thoracic stomach all or nearly all of the stomach is above the diaphragm, being fixed there by reason of the extreme shortness of the esophagus. In Bailey's case "the oesophagus was straight and ended at the level of the third costal cartilage." The pyloric antrum projected into the abdominal cavity only about 6 cm. In Bright's case[5] the esophagus

terminated in the cardiac portion of the stomach at the level of the fourth thoracic vertebra and the pylorus was just above the diaphragm. In the case reported by Bund[6] the esophagus ended just below the bifurcation of the trachea; the pyloric antrum projected through the hiatus oesophageus and lay against the under surface of the liver. More recently Jenkinson[19] has reported a case in which the esophagus was only 3 inches long and entered the stomach opposite the sternoclavicular articulation; the duodenal cap was at the level of the diaphragm and was directed downward.

With so short an esophagus it is obvious that the stomach could never have been below the diaphragm but must of necessity have remained within the thorax. This therefore is not properly a hernia, since the term hernia requires that a once normally placed organ be shifted so that it protrudes through the wall of the cavity normally containing it.

It is worthy of note that the thoracic stomach is not incompatible with long life, Bailey's case having lived to the age of seventy-seven years. The history of the case is rather fragmentary but there is no note of any gastric disturbance and the man was said to have died of arteriosclerosis and interstitial nephritis.

In each of the above reported cases there was a well-defined serous sac completely surrounding the stomach but communicating with the peritoneal cavity. In none of these cases was any other abdominal organ found within the chest.

The case reported by Hume[17] perhaps belongs to this group, but he does not state definitely at just what level the esophagus terminated or just how much of the stomach was above the diaphragm.

2. Diaphragmatic Hernia with Short Esophagus. This term is not strictly correct because here again the condition is not one of herniation of a once normally placed organ. The term, however, has been accepted by a number of authors and is a fairly descriptive one. In this group, as in the previous one, the stomach is always surrounded by a well-defined serous sac and in this regard, therefore, these cases are true herniae.

The esophagus is definitely shorter than normal, although the shortening is not so marked as in the previous group. Here the termination is usually opposite the seventh or eighth thoracic vertebra, whereas in the previous group it terminated in the region of the fourth thoracic vertebra. Due to the shortening of the esophagus a part of the stomach is in the posterior mediastinum, but the displaced portion in these cases is usually less than one-half.

Although these first two groups of cases are similar in that both have congenital shortening of the esophagus, it seems wise to separate them in order that the second group may be more clearly differentiated from the much larger number of cases of hiatus hernia. It is particularly important that this differentiation be made because the hiatus hernia can be repaired by surgery, whereas the patient with the short esophagus cannot be helped in that manner. A case of thoracic stomach should be easily diagnosed by roentgenoscopy because of the marked abnormality of the esophagus, but some care and experience are necessary in determining the actual length of the esophagus when the difference between the normal and the abnormal is only a few centimeters.

In the patient having a diaphragmatic hernia with a short esophagus, the esophagus passes downward through the posterior mediastinum in an almost straight line and enters the displaced stomach in its uppermost part. Instead of the usual rounded fundus the upper end of the stomach in these cases is narrowed and frequently has the appearance of a dilated portion of the esophagus. In the hiatus hernia, on the other hand, the termination of the esophagus is frequently above the diaphragm but a careful study of its lower third will show that this high point of termination is due to tortuosity and not to shortening. It will also be noted that in cases of hiatus hernia

the fundus of the stomach has the same smoothly rounded contour as that normally seen below the diaphragm, and further that the point of entrance of the esophagus into the stomach is slightly to one side rather than at the apex.

If the esophagus is short the stomach must of necessity remain at least in part within the chest at all times. Hence in cases of this type the displacement of the stomach should be visualized even when the patient stands erect, although it may not be possible to fill completely the intrathoracic portion of the stomach in this position. Careful observation of the first few swallows of barium will thus in many cases serve to differentiate this condition from hiatus hernia, since in the latter condition the hernia is frequently present only when the patient is in the supine or Trendelenburg position. Hiatus herniae may be visualized in the erect position only if they are large or are adherent to the surrounding structures.

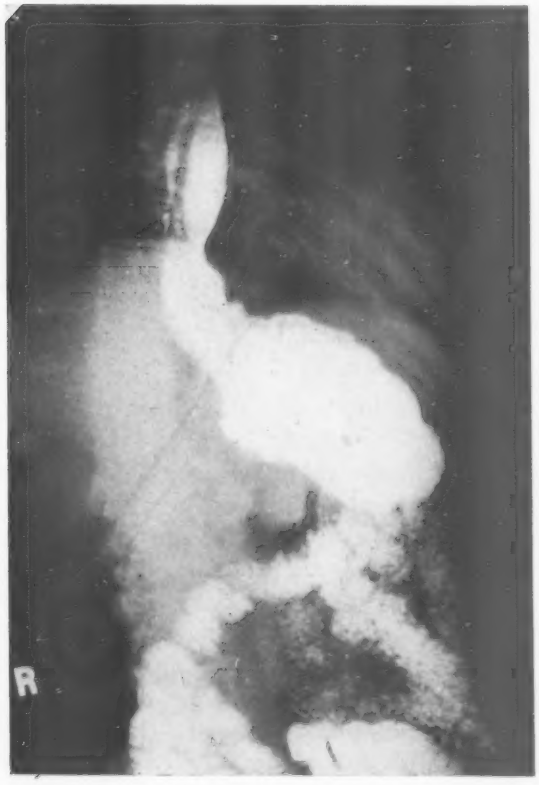


Fig. 3. Case 1. Diaphragmatic hernia with short esophagus. Thickening of mucosa at junction of esophagus with stomach, also at level of diaphragm.

Fig. 4. Case 1. Six and one-half months after attempted reduction of the hernia. More marked narrowing at junction of esophagus and stomach.

Although there is now quite general agreement that the anomaly of a short esophagus is not as rare as was previously thought, there is no general agreement as to just where the fault lies in producing the anomaly. Bailey,[2] in discussing his case of thoracic stomach, believed that the primary defect was in the primitive gut and supposed that "the anlage of the stomach lay abnormally far anterior on the alimentary canal." Anatomists agree that the pleuroperitoneal recesses around the stomach develop before the descent of the diaphragm. This being true, Bailey believed that the diaphragm as it descended would necessarily leave above it not only the misplaced stomach but also the extensions of the peritoneal cavity. The embryonic pleuroperitoneal recesses would thus

Fig. 5. Case 11. Diaphragmatic hernia with short esophagus.

form the serous sac around the thoracic portion of the stomach. Bund[6] had earlier suggested a similar origin of the sac. Åkerlund[1] has suggested that the shortened esophagus is not the primary defect but is secondary to failure of fixation of the lower end of the esophagus as a result of a persistent right or left pleuroperitoneal recess. Jackson and Jackson[18] have studied a number of these cases and are of much the same opinion, believing that the esophagus is not congenitally short but that it has failed to grow. They believe that the vertical growth of the esophagus is dependent upon the downward drag of the diaphragm and abdominal viscera and that if the hiatus is congenitally large, this drag on the growing esophagus is lacking.

The first well-authenticated case of diaphragmatic hernia with short esophagus was reported by Tonndorf[32] in 1920. Small groups of proved cases were reported during the following decade. In 1930 Findlay and Kelly[11] reported a series of 9 children suffering from vomiting and dysphagia in whom a congenital esophageal constriction was found. In 7 of the 9 cases the constriction was opposite the seventh thoracic vertebra. Carefully controlled endoscopy with biopsy showed typical gastric mucosa below the level of the stricture, thus proving that the esophagus was short and that the stomach was displaced upward into the chest. Clerf and Manges[7,25] have also reported a group of 9 cases, 7 of which were proved by biopsy. Again the strictures were opposite the seventh or eighth thoracic vertebra. Of these cases, 4 were in children and 5 were in adults. In a series of 25 cases of diaphragmatic hernia reported by Dunhill,[8] 19 occurred through the hiatus oesophageus. Of these, 14 were thought to have a short esophagus; and although this number suggests an unusually high incidence of this type of hernia, his reproductions leave no doubt as to the correctness of his diagnosis.

It is of interest that in all of these cases of diaphragmatic hernia with shortening of the esophagus the esophagogastric junction is at the level of the seventh or eighth thoracic vertebra. It is not yet clear why the short esophagus should be so nearly the same length in all of these cases but it is an added reason why this group should be separated from the smaller number of cases included under the title of "thoracic stomach."

The case reported by Huffman[16] in 1920 is frequently included with those having a short esophagus but probably belongs in the group of hiatus herniae. His report states that the esophagus terminated at a point 3 cm. above the diaphragm but his drawing suggests that this may have been due to tortuosity. He also states that the greater curvature of the stomach was directed upward, and this is a common finding in cases of hiatus hernia in which a relatively large portion of the stomach is above the diaphragm.

Most authors are agreed that surgery is of little or no benefit in these cases, although Harrington[13] in 1933 reported 4 cases in which he sutured the diaphragm above the stomach following phrenicot-

omy. Monkhouse and Montgomery[26] report that Gordon-Taylor plicated the thoracic portion of the stomach with relief. Other surgeons who have attempted to operate on this condition have found that the esophagus could be stretched sufficiently to bring the stomach down below the diaphragm but that it could not be held in that position.

Of the 2 cases of short esophagus which I have seen both had definite constriction at the junction of the esophagus with the stomach. In both, this junction and the narrowing were opposite the eighth thoracic vertebra, thus being at least 6 cm. above the hiatus in the diaphragm. One of these cases was in a woman aged forty-four and has already been reported by Truesdale.[33] Her symptoms were of about three years' duration and were first noted in 1930 while pulling on a frozen clothes-line at which time she felt as if something had suddenly given way in her left upper chest. Following that she had severe pain in the upper abdomen and her attending physician diagnosed the attack as biliary colic. She soon recovered from the severe pain but a feeling of fullness in the epigastrium persisted. During the nine months prior to admission the pain again became more severe. It was epigastric and substernal and radiated to the back and to the left arm. She was operated upon and reduction of the hernia was attempted but subsequent roentgen examination showed no apparent change in the level at which the esophagus joined the stomach. The gastric rugae always appeared thickened and tortuous at the level of the diaphragm and it is noteworthy that she obtained considerable relief from a modified Sippy regimen.

Fig. 6. Case III. Hiatus hernia. In this position the esophagus appears short and seems to enter the uppermost part of the stomach.

Fig. 7. Case III. Esophagus now shown to be of normal length.

The second patient belonging to this group was a man aged sixty-three whose symptoms were of about six years' duration. His complaints were of dull pain across the upper abdomen and difficulty in swallowing. He had been followed for several years in the gastrointestinal clinic of the Peter Bent Brigham Hospital and was known to have a duodenal ulcer, but he obtained no relief from a Sippy regimen and it was the opinion of the gastroenterologists that his symptoms were not due to

Fig. 8. Case iv. Large hiatus hernia. Gas bubble behind the heart and reaching almost to lateral chest wall.

his ulcer. Roentgen examination was done on four occasions by Dr. M. C. Sosman and twice by myself. At all examinations it was felt that the esophagus was definitely short. There was constriction at the junction of the esophagus with the stomach and slight delay in the passage of solid food through this area. The films of this man and also those of the first patient are very similar to the reported cases of children who were thought to be suffering from congenital strictures.

3. Hiatus Hernia. The third type of diaphragmatic hernia to be considered is that of the hiatus hernia. This is by all odds the most common type of diaphragmatic hernia and is usually found in women over forty years of age who are overweight. In the group of 17 cases in this series all but 2 were in women, the youngest of whom was thirty-eight years of age. The average age of the group was fifty-one years. Excess weight is in all probability a very definite factor in the development of a hernia at the esophageal orifice, although other causes of increased intra-abdominal pressure may also play a part in some cases.

The variation in size of the hiatus oesophageus has already been referred to, and it seems reasonable to believe that if the hiatus be of the relaxed type any increase in pressure within the abdomen might force the stomach up through the opening. More than the normal amount of fat in the omentum may be the cause of this increased pressure or it may be the result of an ovarian cyst, a large fibroid or a pregnant uterus. One of the cases in this series was a heavy-set woman who had a fibroid which reached about midway between the symphysis and the umbilicus. The degenerative changes which result in a lack of tone of all of the muscular structures of the body probably play a part in the production of the relatively large number of cases of small herniae which are found in elderly individuals of both sexes.

Hiatus herniae are true herniae in the

Fig. 9. Case iv. Lateral view in horizontal position. Esophagus of normal length. Inversion of stomach.

sense that the stomach was once in its normal position below the diaphragm. They are invested by a serous sac and are therefore true herniae in that regard also. The esophagus is of normal length. Its point of entrance into the stomach may be above the diaphragm, but careful examination will show that this is due to tortuosity and not to actual shortening.

Several authors have chosen to subdivide the group of hiatus herniae depending on whether or not the esophagus extended below the diaphragm. Eppinger[10] in 1904 was the first to suggest the term "para-esophageal hernia" to describe the type in which the lower end of the esophagus was fixed below the diaphragm and the cardiac end of the stomach passed upward closely adjacent to it. The type in which the lower esophagus is not fixed but has withdrawn into the chest has been referred to[1] as the "acquired type" of hiatus hernia. The latter type is the one most often seen in elderly individuals,[31] but the attempted differentiation seems confusing and unnecessary since both types are acquired and both may be successfully repaired if the symptoms warrant.

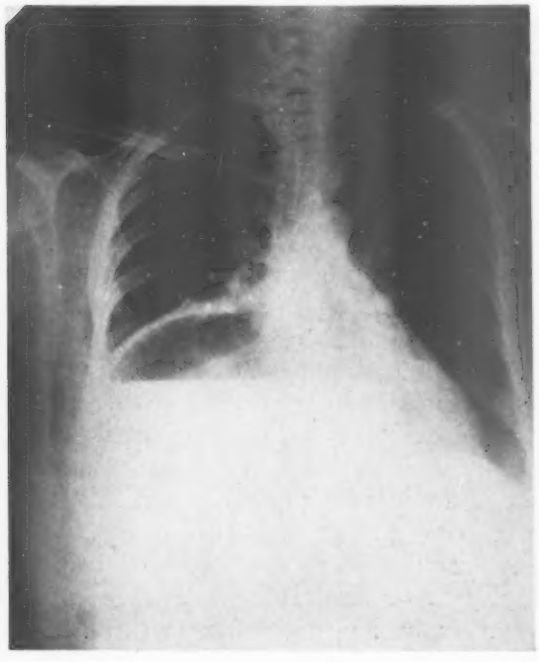


Fig. 10. Case v. Large hiatus hernia with stomach in right side of chest.

Fig. 11. Case v. Shows esophagus of normal length. Other studies showed the colon also involved.

Hiatus herniae vary in size from those so small that they must be differentiated from diverticulum of the lower esophagus to those which include the entire stomach and must therefore be differentiated from the true thoracic stomach. In most cases the stomach is the only organ involved; but if a large part of the stomach has passed through the opening, the colon may also be included because of the attachment of the gastrocolic omentum.

It should be remembered that in most cases of the hiatus type the hernia is not present when the patient is in the erect position. It is usually best seen and most nearly filled with the patient in the supine or Trendelenburg position and with the right chest slightly forward. If the hernia is present in the erect position it is indicative of adhesions. In the present series of 17 cases, the hernia was visualized as a gas bubble above the diaphragm in 4 cases even before barium was given. In 2 of these the hernia was very large and contained a fluid level as well as the gas bubble.

Case IV is of particular interest because of the inversion of the stomach. This patient was a housewife aged fifty-two who had been well until about six years before admission when she had a severe attack of epigastric pain. The pain was at first thought to be due to gallstones but cholecystograms showed a normal gallbladder without evidence of calculi. Examination of the gastrointestinal tract by Dr. L. A. Martineau of Providence in March, 1930, showed a rather large hiatus hernia, the cardiac end of the stomach being above the left diaphragm. Similar attacks of severe epigastric pain occurred several times each year during the next five years. The patient was admitted to the Truesdale Hospital in November, 1935. At that time roentgen examination showed the cardiac end of the stomach within the abdomen but the stomach then turned sharply upward and passed through the diaphragm so that its antrum was in the left chest behind the heart. There was a gastric residue at forty-eight hours in spite of aspiration of the proximal or abdominal loculus. At operation the hernia was shown to occur through the hiatus oesophageus but the stomach was inverted and the pylorus was obstructed due to torsion.

In the great majority of hiatus herniae, the displaced portion of the stomach remains for the most part to the left of the midline. In very large herniae, however, the stomach may lie to the right of the midline. In these the intrathoracic portion is usually rotated on an axis passing through its cardia so that the greater curvature is uppermost. One of our cases had the stomach on the right side, the greater curvature uppermost and a loop of colon also involved.

A review of the histories presented by the patients in this series shows that the most common complaint was distress after meals. This distress was usually described as a feeling of fullness in the upper abdomen, although at times the patient felt as if something were pressing against the heart. The entire history given by the patient was frequently suggestive of gallbladder disease and in an almost equal number of cases it was very suggestive of angina pectoris. Only 3 of the 17 cases complained definitely of difficulty in swallowing. One very intelligent woman had noted that she obtained relief by lying in the prone position. This is of interest from the roentgenological standpoint since in many cases the hernia is not present in the prone position; in still others it is present in this position but is only partially filled.

Only 2 patients gave any history of gross hemorrhage. One stated that she had vomited a large amount of fresh blood ("more than 3 quarts") about three months before and that her stools had been tarry for several days. Her red blood cell count on admission was 4,150,000. One other patient had vomited blood eighteen years previously but it is doubtful if this was associated with her hernia.

Bock, Dulin and Brooke[4] in 1933 reported a series of 10 cases of hiatus hernia suffering from secondary anemia, 3 of whose red counts were below 3,000,000. The average count for the group was 3,443,000. Frequently their stools gave positive tests for occult blood. In our series of cases the average count was 4,030,000 and although 7 were below 4,000,000 not much attention was paid to the anemia. Occult blood was found in the stools only 3 times in 11 examinations on 9 patients.

4. Congenital Hernia. The congenital herniae are in many respects the most interesting of all the diaphragmatic herniae. It is in this group that we find the greatest departure from the normal, as well as variation in the organs involved and variation in the site of herniation. As the name implies, they are most commonly found in infants and children. They are often dramatic in their clinical course and they are frequently the cause of death by asphyxia or intestinal obstruction. Their symptomatology is often related more closely to the respiratory system than to the alimentary tract by reason of the displacement of the mediastinum and the

compression of the lung. The diagnosis can usually be made quite readily by physical examination due to the abnormal position of the heart and the multiplicity of the sounds heard over the displaced bowel.

The great majority of congenital herniae are found on the left side and occur through a persistent hiatus pleuroperitonealis or foramen of Bochdalek. As has been pointed out above, this opening is the result of a failure of fusion of the posterior and lateral segments of the diaphragm. Many congenital herniae are false, thus suggesting that the fault occurred very early in fetal life and before the division of the celomic cavity was complete. Less commonly the hernia occurs through the parasternal foramen of Morgagni. Here it is usually impossible to tell whether the original opening was on the left or the right side due to the fact that the opening is enlarged or distorted by the passage of the herniated organs. Occasionally the hernia may occur through defects in other parts of the dome of the diaphragm. A few cases have been reported in which the hernia was on the right side and included only a portion of the liver. The diagnosis then is extremely difficult and the mass, even if visualized roentgenologically, is usually interpreted as a localized collection of fluid or pus.

The common type of congenital hernia occurring through the left foramen of Bochdalek frequently includes both the large and small intestines, the stomach, the spleen, omentum, left lobe of the liver, and

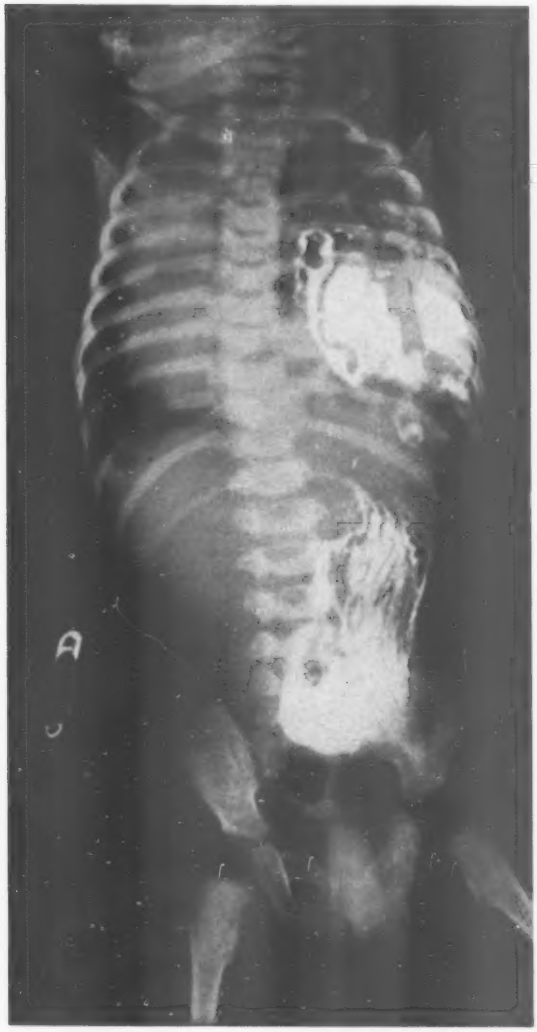


Fig. 12. Case vi. Congenital hernia through foramen of Bochdalek. Thirty minutes after ingestion of barium.

Fig. 13. Case vi. Lateral view shows the opening in the posterior portion of the diaphragm.

Fig. 14. Case vi. Lateral view after barium enema shows colon also passing through the posterior part of the diaphragm.

occasionally other organs. Those which occur anteriorly through the parasternal foramen usually involve only the large and small bowel and the omentum.

Due to the fact that the entire left chest may be filled with abdominal organs, and to the fact that loops of bowel may be seen entering and leaving the chest over a rather wide area, the roentgenologist may be led to wonder whether sufficient diaphragm remains for satisfactory repair or whether the case may be one of congenital absence of the diaphragm. Careful studies in all positions at frequent intervals after the ingestion of barium or after barium by enema will usually give indirect evidence of a shelf-like structure pressing against some of the loops as they pass from one cavity into the other. Occasionally several loops may be seen running horizontally for a short distance, thus suggesting quite definitely that there is a shelf of diaphragm extending inward from the chest wall. In searching for evidence of such remnants of the diaphragm, it must be remembered that the diaphragm may be depressed by the herniated organs above it. Evidence of a sac, if present, may be shown by a thin line of slightly increased density which appears to gather the loops of bowel together into a space somewhat smaller than the thoracic cage. This is well shown in Figure 17.

There may be a definite shift of the

Fig. 15. Case vii. Girl aged ten years. Congenital hernia. Stomach inverted in left chest. Duodenal cap pointing downward at level of diaphragm.

herniated organs during respiration. Two of the patients in this series were able to cooperate so that this shift might be studied. It was well marked in one and the loops of bowel were seen to ascend higher into the left chest on forced expiration. At operation this hernia was shown to be a false one through the left foramen of Bochdalek and there were many dense adhesions between the various loops of bowel and also between the bowel and the margin of the opening.

Of the 6 cases of congenital hernia seen, 4 were similar regarding the site of the hernial opening and the organs displaced. The defect in the diaphragm extended peripherally from a point in the central tendon just to the left of the hiatus oesophageus and reached the chest wall opposite the posterior axillary line. It was assumed in each case that the hernia occurred through the foramen of Bochdalek, although accurate identification of the several segments of the diaphragm was often difficult. In each of these cases all of the small bowel, the proximal two-thirds of the large bowel, the

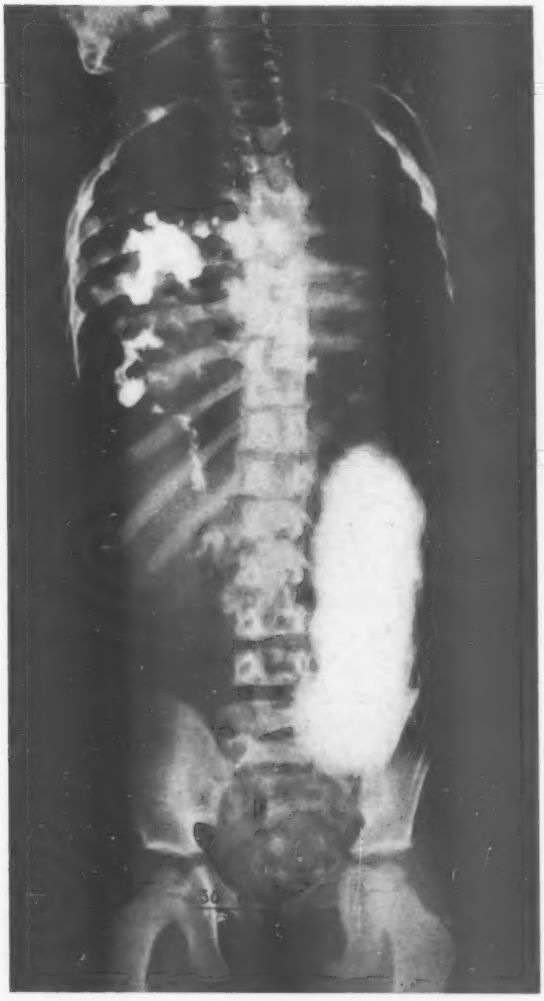


Fig. 16. Case VIII. Girl aged four years. Right-sided diaphragmatic hernia through foramen of Morgagni. Stomach in abdomen. Duodenum directed upward through the diaphragm.

Fig. 17. Case VIII. Lateral view two and one-half hours after ingestion of barium. The opening in the diaphragm is anterior and the herniated loops of bowel are contained within a sac which is faintly shown as an arched line joining the loops of colon.

FIG. 18. Case VIII. Lateral view after barium enema showing colon passing through the foramen of Morgagni.

spleen and the omentum were in the left chest. The fifth case was apparently similar except that the stomach was also in the left chest. It lay close to the midline and its greater curvature was uppermost. The duodenal cap was again at the level of the diaphragm, apparently by reason of the relative fixation of the second portion of the duodenum. In none of these 5 cases was there any evidence of a hernial sac by roentgen examination or at operation. The sixth case occurred through the parasternal foramen, apparently the right. Most of the small bowel and about two-thirds of the colon were in the right chest. This last case was a true hernia with a well-defined sac.

The patients seen in this group were of the following ages: six weeks, three months, four years, nine years, ten years and thirteen years. The 3 older patients in the group have already been reported by Truesdale[35] but it may be noted here that in all except the 2 babies the outstanding symptoms were those of recurring attacks of partial intestinal obstruction. It was necessary that great care be employed in the selection of food so that too much gas would not collect in the loops of bowel within the chest. The girl of ten years whose stomach was inverted in the left chest could eat only small amounts at a time, and on admission to the hospital she weighed only 52 pounds. She had been confined to bed for several months and could not stand alone. Although her bowels were irregular her attending physicians had warned against the use of enemata because of the marked dyspnea and cyanosis when the colon was filled. The symptomatology in the infants was more definitely of a respiratory nature with frequent attacks of dyspnea and cyanosis due to displacement of the mediastinum and compression of the lung.

5. Traumatic Hernia. Traumatic herniae may occur in children or adults and are always false herniae. Interesting statistics regarding the incidence of traumatic hernia have been collected by Hedblom.[15] He found that approximately 90 per cent of the cases occurred in males and that about 50 per cent were due to penetrating injuries. Of those due to non-penetrating injuries only 23 per cent were due to crushing, while 36 per cent were due to falls. The diagnosis of diaphragmatic hernia should therefore be carefully considered in the examination of all persons who have suffered severe injury due to falling. The possibility of hernia is readily associated with crushing injuries but does not seem so clearly related to falling. That it should be remembered is shown by these figures.

Traumatic hernia may occur through

any part of the diaphragm, but 95 per cent are found on the left side. The rent in the diaphragm usually runs radially from the central tendon and frequently extends from the dome to the periphery. The original opening may be only a small one, such as that caused by a rifle bullet, but gradually enlarges in the direction of the muscle fibers extending centrally into the fibrous portion and peripherally to the chest wall. The tendency of the opening to extend the full length of the muscle fibers makes it similar to that of congenital origin, and the number and variety of the organs involved is likewise similar.

Intestinal obstruction is a frequent complication of traumatic hernia due to the dense adhesions formed around the margins of the hernial orifice. These adhesions make operation from below difficult or impossible. Repair of an uncomplicated diaphragmatic hernia is in itself a formidable procedure, and in the event of intestinal obstruction the operative mortality is greatly increased.

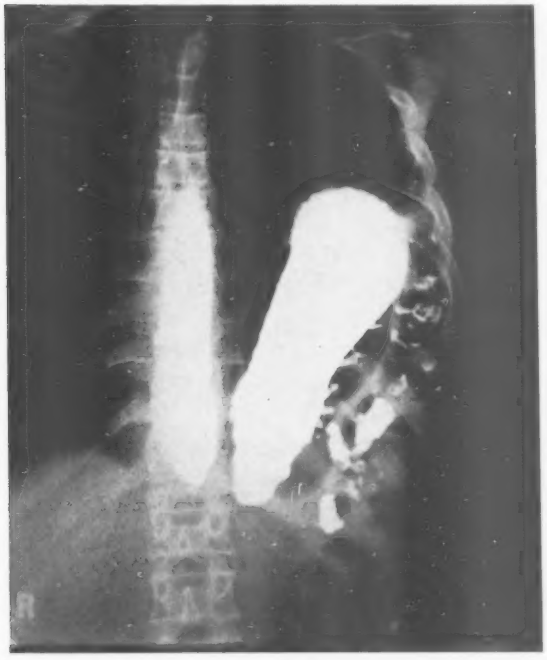


Fig. 19. Case IX. Traumatic hernia. Stomach inverted in left chest with splenic flexure of colon lateral to it.

Fig. 20. Case IX. Barium enema with patient in Trendelenburg position shows the colon extending up to the level of the third rib.

Of the 2 cases of traumatic hernia which I have seen, one was a man aged thirty-nine who had been wounded while serving in the British infantry during the World War. The other was a boy aged eleven who had been struck by an automobile. Both of these cases have been reported elsewhere.[34,35] The war veteran had been operated upon for acute intestinal obstruction about three months following his injury and had been troubled with pain in the left chest thereafter. This pain was more marked after meals and was quite severe about once each day. An attempt was made to repair the hernia at the time he was operated upon for obstruction but the hernia recurred. Roentgen examination in this hospital showed the esophagus of normal length and extending to the diaphragm. The stomach turned sharply upward into the left chest and the splenic flexure of the colon lay lateral to it. There was a marked shift of the herniated loops of bowel coincident with change in position of the patient, but at operation there were

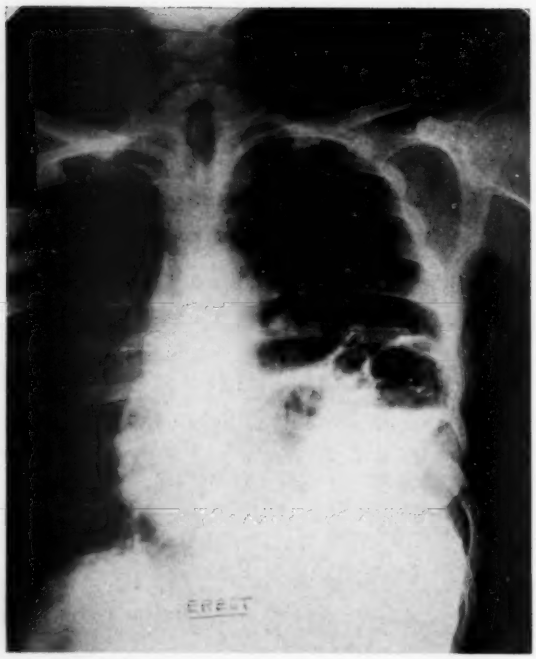


Fig. 21. Case IX. Patient in erect position. Colon still filled with barium enema five minutes after Figure 20.

numerous, dense adhesions. It is of interest that change in position of the misplaced organs is not indicative of absence of adhesions.

The boy had been struck by an automobile at the age of five years while riding his tricycle. More than half of the time during the next six years was spent in hospitals and nursing homes because of frequent attacks of severe pain which was apparently due to partial obstruction. Examination showed the stomach inverted in the left chest as in the previous case. Most of the small bowel and a long loop of the colon were also in the chest. There was slight but definite constriction of the colon as it passed through the diaphragm.

In each of these cases of traumatic origin the cecum was fixed in its normal position in the right lower quadrant. In all of our cases of congenital origin the cecum was in the chest, apparently the result of incomplete rotation of the colon.

6. Eventration of the Diaphragm. Eventration may be congenital or acquired and is the result of aplasia or atrophy of the muscle fibers of the diaphragm. It is a relatively rare condition if we exclude all cases of elevation of the diaphragm due to operations on the phrenic nerves. It is more common on the left side than on the right and is also more common in males than in females. Bilateral cases have been reported[22] and are usually associated with megacolon.

Korns[20] in 1921 published a comprehensive and critical analysis of all of the literature on eventration up to that time. He found much confusion regarding the use of the terms "eventration" and "hernia." After carefully reviewing all of the evidence presented for each reported case, he concluded that there were 22 cases which might be regarded as proved and 43 which he regarded as probable. Of the total of 65 cases, only 6 were on the right side. He states that the first authentic case was that of Jean-Louis Petit[29] which was published by Lesne in 1774.

Korns also called attention to the fact that the phenomenon of paradoxical movement is unreliable and of no diagnostic significance. More recently Moore and Kirklin[27] have stated that the "respiratory movement may be normal, diminished, absent or reversed" in either eventration or hernia.

Korns pointed out the errors in diagnosis which had been made by roentgen examination prior to 1921 and believed the procedure was not of real value. He reviewed the work of Hoover regarding the interaction of the diaphragm and the intercostal muscles in respiration and reasoned that if the diaphragm were elevated it would operate at a disadvantage. The intercostal muscles would then act almost unhindered and would produce a marked excursion of the costal margin on the affected side. On the basis of this excursion of the costal border and of the auscultatory findings in the chest, he states that Hoover was able to make a clinical diagnosis of aplasia of the right lung and right half of the diaphragm. The diagnosis was then *confirmed*

by roentgenoscopic examination and the case was included as one of the 4 *proved* cases of right-sided eventration.

With the more thorough knowledge of eventration and hernia which has come during the past fifteen years, the findings of the roentgenologist are more trustworthy and he is now relied upon to differentiate these two conditions. The diagnosis of eventration is of course dependent upon the demonstration of an elevated but intact diaphragm. Such a demonstration may at times be very difficult. A crescentic shadow above the displaced viscera may be visualized but may represent an elevated diaphragm or the sac of a true congenital hernia. Lord[24] was among the first to point out that this arched line might not be the diaphragm. If the diaphragm cannot be demonstrated in the right anterior oblique or lateral positions, it may occasionally be demonstrated by the production of a pneumoperitoneum. Care must be taken in the interpretation of the findings even here, since the injected air might rise and be confined by a hernial sac in the same manner in which it would collect beneath an eventrated diaphragm. If the shadow produced be that of a hernial sac, it should be possible to demonstrate some drawing together of the loops of bowel at the neck of the sac. Such drawing together would not be noted in the case of eventration.

Fig. 23. Case x. Stomach inverted beneath high left diaphragm.

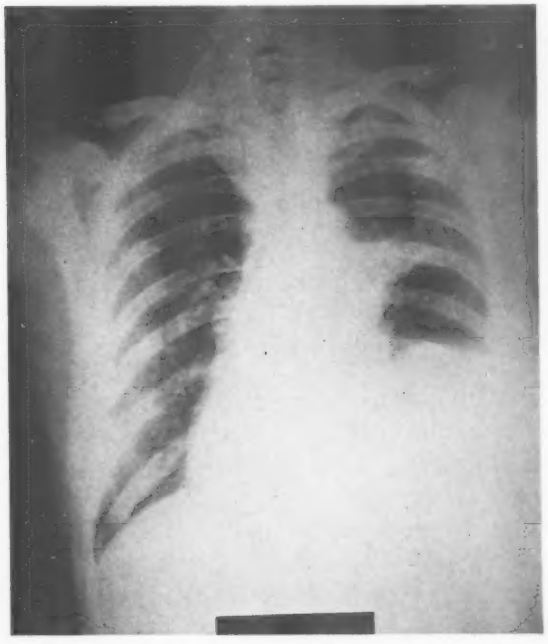


Fig. 22. Case x. Eventration of left diaphragm. Left hilar shadow shows fibrosis and few small calcified nodules.

The symptomatology of eventration is much less marked than that of hernia. The condition may be almost entirely asymptomatic and the diagnosis be suspected simply because the heart is found on the right side. Some patients, however, experience a certain amount of distress in the left lower chest, probably as a result of collection of gas in the stomach above the level of the cardiac orifice. Symptoms of this type are frequently seen in cases of pulmonary tuberculosis after left phrenectomy but are usually not severe. They are not seen after operations on the right phrenic nerve.

Two cases have been reported[9,21] in which plication of the eventrated left diaphragm was done for relief of symptoms and in both the postoperative roentgen examination showed that the diaphragm had been brought down to a more nearly normal level.

One man, aged fifty-nine, has been seen here whose left diaphragm was elevated and whose chief complaint was shortness of breath. He had been thrown to the ground while trying to board a moving train thirty years before, at which time he was badly shaken up and three ribs on the left side were fractured. He had no definite gastrointestinal complaints except for distress in the left upper abdomen and left lower chest. His appetite had always been good and his bowels moved regularly without medication. On examination, his right diaphragm was opposite the upper margin of the eleventh rib and the left was 10 cm. higher, being opposite the eighth interspace in the scapular line. There was only slight movement of the left diaphragm with respiration but this appeared to be in the normal direction. The left hilar shadow was elevated, being opposite the seventh rib posteriorly. There were a few small calcified nodules within the hilar shadow and there was rather marked fibrosis extending outward from it. The esophagus appeared normal in every respect but the stomach turned sharply upward into the left chest beneath the high diaphragm. The splenic flexure of the colon was just lateral to the stomach and on several occasions it was seen to contain a rather large collection of gas. The emptying time of the stomach was normal and there was no evidence of obstruction in the colon. It was thought that the left phrenic nerve had been involved in an old tuberculous process in the left lung root, but no operative procedure seemed advisable.

It is of some interest that this man had been confined to a sanatorium for almost a year in 1908 because of the physical signs in his left chest. Exploratory thoracentesis had been done on several occasions but no fluid had been obtained.

7. Congenital Absence of the Diaphragm. Congenital absence of the diaphragm must always be included in the differential diagnosis of diaphragmatic hernia although it is a rare condition. In 1933 Sagal[30] was able to collect only 12 cases from the literature and several of these were not definitely proved.

A study of the pressure relationships within the chest and abdomen shows that the pressures within the body of the patient having congenital absence of the diaphragm are exactly similar to those within the body of the patient having a large false hernia of the congenital or traumatic type. It is thus readily seen that even so marked an anomaly as this is not incompatible with life, and it should be borne in mind that the mammals are the only members of the animal kingdom which possess a diaphragm.

The oldest proved case in the literature is that of Harris and Clayton-Greene.[14] Their patient was a woman aged thirty-one who was married and had two children. Roentgenograms of her chest were at first interpreted as pleural effusion and later as hernia. She was operated upon but no diaphragm was found on the left side. Beckman's[3] case was a boy aged seventeen who had had "stomach trouble" all of his life. He was operated upon by Dr. W. J. Mayo who found congenital absence of the diaphragm and lung on the left side. The left chest was filled with intestines but the stomach, which was greatly dilated, had remained within the abdomen. Jenkinson[19] has reported 3 proved cases, 2 of them in infants who died of respiratory failure, and one in a girl of six years. The 3 cases reported by LeWald[23] were so diagnosed by roentgen ray but were not proved by operation or autopsy.

It is my opinion that the diagnosis of congenital absence of the diaphragm should be carefully considered by the roentgenologist when studying cases of diaphragmatic hernia and associated conditions, especially those of congenital origin. It seems unwise, however, to consider this diagnosis as

proved unless the patient is subjected to an exploratory operation by a competent surgeon. Such an operation is of primary importance to the patient since the danger of obstruction is a very definite one if the condition is actually one of hernia. In the 6 cases of congenital hernia which I have seen there was never any serious doubt that at least fragments of diaphragm would be found at operation, but the roentgenographic evidence of these portions of the diaphragm was in at least 2 of the cases entirely indirect and not as definite as might be desired. Certainly the statement that "in the lateral position the diaphragm can be made out if present" is not true.

SUMMARY

An attempt has been made to review the salient features of the various types of diaphragmatic hernia. The study has been based upon a series of twenty-nine cases seen personally. It has been made primarily from the standpoint of the roentgenologist since it is believed that he can differentiate the various types of hernia and can thus be of help in directing the treatment.

It has been pointed out that the true thoracic stomach is a rare anomaly having a very short esophagus and having all or nearly all of the stomach within the mediastinum. This condition should not be confused with cases in which the esophagus is of normal length, even though the entire stomach has herniated into the chest. The thoracic stomach is not amenable to surgery whereas the hiatus hernia can be repaired if the symptoms warrant.

Diaphragmatic hernia with short esophagus must also be differentiated from the hiatus hernia since the congenitally short esophagus prevents satisfactory surgical repair. Those with the short esophagus are also of interest because they so often have constriction at the junction of the esophagus with the stomach and hence suffer from difficulty in swallowing.

The congenital and traumatic herniae are often similar as to their site and as to the number of organs involved. Both are usually false herniae and both may be the cause of intestinal obstruction. The symptoms and objective findings of the congenital type are frequently related even more closely to the respiratory system than to the gastrointestinal tract and death may result from suffocation. The congenital herniae are usually associated with incomplete rotation of the colon.

Eventration of the diaphragm is a relatively uncommon condition and the symptoms are usually much less marked than those of hernia, due to the fact that there is no hernial orifice constricting the misplaced loops of bowel. Reference is made to the difficulty occasionally encountered in differentiating eventration from congenital true hernia.

Congenital absence of the diaphragm is a rare condition which must be considered in the differential diagnosis of congenital hernia but which should not be finally diagnosed by the roentgenologist.

I wish to express my thanks to Dr. P. E. Truesdale for permission to review this series of cases and to Dr. M. C. Sosman for his helpful criticism.

REFERENCES

1. Åkerlund, Å. Die anatomische Grundlage des Röntgenbildes der sogen. "erworbenen Hiatusbrüche." *Acta radiol.*, 1933, *14*, 523–544.
2. Bailey, P. Case of thoracic stomach. *Anat. Rec.*, 1919, *17*, 107.
3. Beckman, E. H. Diaphragmatic hernia, with report of three cases. *Surg., Gynec. & Obst.*, 1909, *9*, 154–156.
4. Bock, A. V., Dulin, J. W., and Brooke, P. A. Diaphragmatic hernia and secondary anemia; report of ten cases. *New England J. Med.*, 1933, *209*, 615–625.
5. Bright. Account of a remarkable misplacement of the stomach. *Guy's Hosp. Rep.*, 1836, *1*, 598–603.
6. Bund, R. Ein Fall von rechtsseitiger Hernia diaphragmatica mit Austritt des Magens in den persistierenden Rezessus pneumatoentericus dexter. *Frankfurt. Ztschr. f. Path.*, 1918, *21*, 243–257.
7. Clerf, L. H., and Manges, W. F. Congenital anomalies of the esophagus, with special reference to the congenitally short esophagus with a portion of the stomach above the diaphragm. *Ann. Otol., Rhin. & Laryng.*, 1933, *42*, 1058–1068.

8. DUNHILL, T. Diaphragmatic hernia. *Brit. J. Surg.*, 1935, *22*, 475–499.
9. DUVAL, P., and QUÉNU, J. Éventration diaphragmatique gauche, sans mégacôlon splénique. *Bull. et mém. Soc. nat. de chir.*, 1924, *50*, 178–193.
10. EPPINGER, H. Allgemeine und spezielle Pathologie des Zwerchfells. A. Hölder, Wien and Leipzig, 1911.
11. FINDLAY, L., and KELLY, A. B. Congenital shortening of the oesophagus and the thoracic stomach resulting therefrom. *J. Laryng. & Otol.*, 1931, *46*, 797–816.
12. GIFFIN, H. Z. Diagnosis of diaphragmatic hernia. *Ann. Surg.*, 1912, *55*, 388–399.
13. HARRINGTON, S. W. Diaphragmatic hernia; symptoms and surgical treatment in 60 cases. *J. Am. M. Ass.*, 1933, *101*, 987–994.
14. HARRIS, W., and CLAYTON-GREENE, W. Congenital absence of the left half of the diaphragm, simulating pneumothorax. *Proc. Roy. Soc. Med.*, 1911–1912 (*Clin. Sect.*), *5*, 153–156.
15. HEDBLOM, C. A. Diaphragmatic hernia. *Ann. Int. Med.*, 1934, *8*, 156–176.
16. HUFFMAN, L. F. Case of diaphragmatic hernia observed post-mortem. *Ann. Surg.*, 1920, *72*, 665.
17. HUME, J. B. Congenital diaphragmatic hernia. *Brit. J. Surg.*, 1922, *10*, 207–215.
18. JACKSON, C., and JACKSON, C. L. Peroral gastroscopy including examination of supradiaphragmatic stomach. *J. Am. M. Ass.*, 1935, *104*, 269–275.
19. JENKINSON, E. L. Absence of half of the diaphragm (thoracic stomach; diaphragmatic hernia). AM. J. ROENTGENOL. & RAD. THERAPY, 1931, *26*, 899–903.
20. KORNS, H. M. Diagnosis of "eventration" of the diaphragm. *Arch. Int. Med.*, 1921, *28*, 192.
21. LERCHE, W. Insufficiency (eventration) of the diaphragm. *Surg., Gynec. & Obst.*, 1922, *34*, 224–229.
22. LEWALD, L. T. Thoracic stomach; differentiation from eventration and hernia of the diaphragm. *Radiology*, 1924, *3*, 91–104.
23. LEWALD, L. T. Congenital absence of left half of diaphragm. *Arch. Surg.*, 1927, *14*, 332–344.
24. LORD, F. T. Eventration of the diaphragm. *Arch. Surg.*, 1927, *14*, 316–329.
25. MANGES, W. F., and CLERF, L. H. Congenital anomalies of the alimentary tract, with special reference to the congenitally short esophagus. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *33*, 657–669.
26. MONKHOUSE, J. P., and MONTGOMERY, S. K. Report of seven cases of partial thoracic stomach with short oesophagus. *J. Laryng. & Otol.*, 1933, *48*, 743–753.
27. MOORE, A. B., and KIRKLIN, B. R. Progress in the roentgenologic diagnosis of diaphragmatic hernia. *J. Am. M. Ass.*, 1930, *95*, 1966–1969.
28. PANCOAST, H. K., and BOLES, R. S. Nontraumatic left diaphragmatic hernia. *Arch. Int. Med.*, 1926, *38*, 633–646.
29. PETIT, J.-L. Traité des maladies chirurgicales, et des opérations qui leur conviennent. T.-F. Didot jeune, Paris, 1774, vol. 2, 226.
30. SAGAL, Z. Absence of left diaphragm associated with inverted thoracic stomach. AM. J. ROENTGENOL. & RAD. THERAPY, 1933, *30*, 206–214.
31. SCHATZKI, R. Die Beweglichkeit von Oesophagus und Magen innerhalb des Zwerchschlitzes beim alten Menschen. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1932, *45*, 177–187.
32. TONNDORF, W. Wahre Zwerchfellhernien als Folge einer Wachstumshemmung der Speiseröhre. *Deutsche Ztschr. f. Chir.*, 1923, *179*, 259–265.
33. TRUESDALE, P. E. Diaphragmatic hernia at the esophageal hiatus, short esophagus and thoracic stomach. *New England J. Med.*, 1935, *212*, 240–250.
34. TRUESDALE, P. E., and PHIPPEN, W. G. Traumatic diaphragmatic hernia following war injuries. *New England J. Med.*, 1935, *212*, 597–602.
35. TRUESDALE, P. E. Diaphragmatic hernia in children with a report of 13 operative cases. *New England J. Med.*, 1935, *213*, 1159–1172.

Vol. 37, No. 5

ROENTGENOLOGIC STUDIES OF THE LIVER AND SPLEEN*

By CHARLES L. MARTIN, E.E., M.D., F.A.C.R.
Professor of Radiology, Baylor University Hospital
DALLAS, TEXAS

LESIONS in the upper abdomen provide some of the most difficult diagnostic problems met with in medicine, and laboratory aid of any sort is usually much appreciated by clinicians. Pfahler[5] has shown that good films made in the anteroposterior position with a 25 inch target film distance usually outline the under border of the liver so that its shadow can be measured, assuming that its upper border and the diaphragm are identical in position. He made use of two dimensions. The "length" of the liver was measured from the lower right edge to the highest point on the upper border of the right lobe. In a large series of normal individuals the average figure for this measurement was 21.3 cm., with extreme limits of approximately 18.0 to 22.0 cm. The other dimension was called the thickness or "width" of the liver and was measured from the highest point on the right lobe to the midportion of the lower border. This measurement averaged 12.8 cm., with extreme figures of approximately 10.0 to 14.0 cm.

Unfortunately, the spleen is rarely visualized in ordinary films and its study requires a more specialized procedure. Radt,[6] in 1928, demonstrated the liver and spleen in roentgenograms made following the intravenous injection of thorium dioxide which is deposited in the cells of the reticulo-endothelial system and thereby renders visible the organs containing this system. Yater and Otell[9] have recently described the method and have observed that the concentration of the injected material in the liver as well as its homogeneity are of some diagnostic importance. Observations made over a period of several years indicate that thorium dioxide is retained permanently in the reticulo-endothelial system, and it has not been used in our laboratory because of the possible late effects on the tissues of its mild radioactivity.

Although pneumoperitoneum was popularized in this country by Stewart and Stein[8] in 1919 and has been utilized by a few others since, it has never received the recognition that it deserves. The usefulness of the procedure was greatly augmented when Alvarez[1] discovered in 1921 that carbon dioxide was safe for intraperitoneal injection. Its rapid absorption from the abdomen reduces the period of discomfort for the patient to less than an hour and makes the method a practical one. The details of the technique were described in a paper[4] written many years ago (1922). Since the target film distance used by Pfahler is also used for pneumoperitoneum films, his measurements for the normal liver may be utilized in this work. No figures for the size of the splenic shadow are available but we have adopted a length of 10 cm. as an average normal after studying a series of our own films. Not only can the size and shape of the liver and spleen be demonstrated, but adhesions about them can also be outlined. In many instances, the exact identity of an upper abdominal mass is in doubt and the use of pneumoperitoneum shows either that it is an enlarged liver or spleen or some extraneous mass such as a kidney, a mesenteric tumor, a retroperitoneal neoplasm or a pancreatic new-growth. The procedure is also of great value in studying the cause of unexplained ascites. Oftentimes after changes in the liver and spleen have been clearly delineated on the film, the determination of the underlying pathology is still quite difficult. This is due to the fact

* Read at the Thirty-seventh Annual Meeting, American Roentgen Ray Society, Cleveland, Ohio, Sept. 29–Oct. 2, 1936.

that such a large number of diseases may produce these changes. However, a careful history combined with a Wassermann test, blood studies and roentgen examinations of bones and pneumoperitoneum in selected cases should reveal the diagnosis in most instances. The following rather condensed survey of diagnostic possibilities reveals some of the problems encountered.

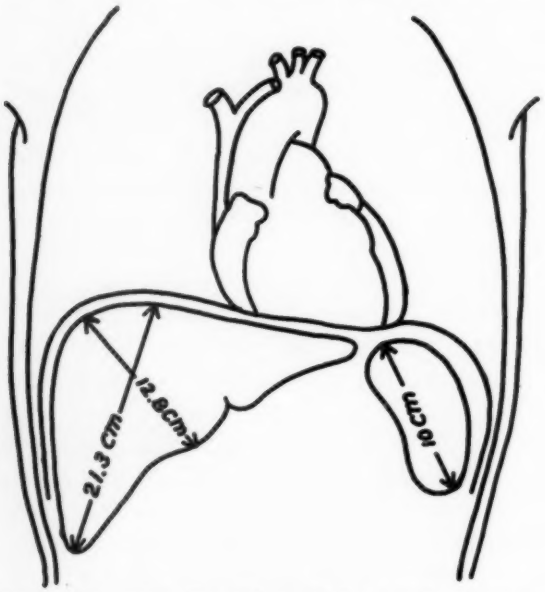


Fig. 1. Average dimensions of liver and spleen as they are portrayed on a pneumoperitoneum film at a 25 inch target film distance.

THE CONTRACTED LIVER

A marked reduction in the size of the liver is usually due either to acute yellow atrophy or atrophic cirrhosis and oftentimes these two conditions are associated.

The liver in acute or subacute yellow atrophy is smooth in outline, soft and flabby and shows a progressive decrease in size during the course of the disease which may last from two weeks to a number of months. The cirrhotic liver is also much reduced in size but its surface is usually irregular because of hobnail-like projections. Even though the roentgenographic appearance of the livers in these conditions is similar, a diagnosis can be made from the histories. In acute yellow atrophy the first symptom is a marked jaundice which is followed in a relatively short time by symptoms indicating the presence of a severe toxemia. The onset of symptoms in cirrhosis is very slow, and jaundice, when it appears at all, comes quite late in the disease and is rarely marked.

Another differential point is the degree of splenic enlargement revealed by the pneumoperitoneum studies. In acute yellow atrophy the spleen may show slight enlargement but in atrophic cirrhosis the splenomegaly is quite pronounced. When patients do not die with acute yellow atrophy and the condition becomes subacute, cirrhotic changes occur in the shrunken liver, and compensatory hypertrophy causes the surface of the organ to become quite irregular. In this stage only cirrhosis can be suspected from the roentgenogram but the history should make the diagnosis evident.

Although the classical case with atrophic cirrhosis possesses a very small liver, many cirrhotic livers are larger than normal. At one time this hepatomegaly was supposed to represent an early stage of the disease but it is now thought that the process may occur late as a result of hyperemia and compensatory hypertrophy in livers which are not completely fibrosed. The atrophic cirrhotic liver has an irregular surface covered with projections which rarely exceed a half inch in diameter, while the large cirrhotic liver may or may not show irregularities on its surface. However, the spleen usually shows definite enlargement in all recognizable stages of the disease.

Table 1 gives the findings in 10 cases studied by pneumoperitoneum at Baylor University Hospital. This material may not be absolutely accurate since the diagnoses were made clinically by the medical department in each instance and were not substantiated by autopsy. Nevertheless, the findings are of interest. Each patient was admitted to the hospital because of a recurring ascites. Only 3 patients had jaundice and one complained of hematemesis. All but one showed some secondary

anemia. In 3 patients the livers were enlarged and 2 of these had nodular surfaces. In the 7 livers showing atrophy, the average length was 16.1 cm. (5.2 cm. below normal), and the average width was 11.2 cm. (1.6 cm. below normal). All of the spleens were definitely enlarged and this disease. The discovery of a very large liver should therefore always suggest the presence of carcinoma unless the blood studies show the presence of leukemia or an adenopathy suggests the presence of Hodgkin's disease. Hodgkin's disease is occasionally limited to a large liver in which

TABLE I

CASES OF CIRRHOSIS OF THE LIVER

	Age	Ascites	Jaundice	Hemorrhage	Edema	Hemoglobin	Red Blood Cells	White Blood Cells	Liver			Spleen	
									Length cm.	Width cm.	Surface	Diameter cm.	Adhesions
1	17	+	+	+	+	60%	2,755,000	7,575	14.5	10.5	Slightly nodular	16.0	Many
2	57	+	−	−	+	70%	3,720,000	4,000	17.5	13.5	Adhesions	23.0	None
3	40	+	+	−	+	75%	3,940,000	5,400	15.5	11.1	Slightly nodular	18.5	None
4	72	+	−	−	+	69%	3,350,000	5,700	15.5	12.0	Smooth	15.5	None
5	35	+	−	−	+	51%	2,450,000	6,200	16.5	10.0	Hobnail	17.2	None
6	41	+	−	−	+	85%	4,160,000	3,900	17.0	9.0	Hobnail	21.0	None
7	72	+	−	−	+	65%	3,400,000	3,550	16.2	12.5	Slightly nodular	20.0	None
8	30	+	+	−	−	90%	5,000,000	10,100	20.5	18.0	Smooth	15.0	None
9	57	+	−	−	+	75%	3,820,000	11,500	18.0	14.5	Large nodules	18.0	None
10	62	+	−	−	+	75%	3,525,000	6,175	25.5	22.5	Large nodules	15.5	None

enlargement varied from 50 to 110 per cent of the average normal.

THE VERY LARGE LIVER

All degrees of hepatic enlargement can be demonstrated by pneumoperitoneum. Recently Barron and Litman[2] have shown that the degree of this enlargement is of real diagnostic importance. In a study of 12,000 autopsies they found only four causative agents responsible for 58 very large livers (weighing 4,000 gm. or more). In this series, 48 were produced by malignancy; 5 by melanoma; 2 by leukemia; 2 by amyloidosis, and one by Hodgkin's event its presence can be suspected only when the patient has the Pel-Ebstein type of relapsing pyrexia.

Although Barron and Litman observed only 2 large livers resulting from amyloid disease, Rolleston[7] states that one such organ has been observed weighing 6,400 gm. It was smoothly enlarged and accompanied by an enlarged spleen. Nodules, usually of considerable size, are seen on the surface of most malignant livers and they are of much diagnostic importance, especially when they are umbilicated. In the presence of a large smooth liver, amyloid disease must be suspected when syphi-

lis or long-continued suppuration is also present.

THE MODERATELY ENLARGED LIVER

All of the very large livers must at some time have a moderate size, and carcinoma, melanoma, leukemia, amyloidosis and

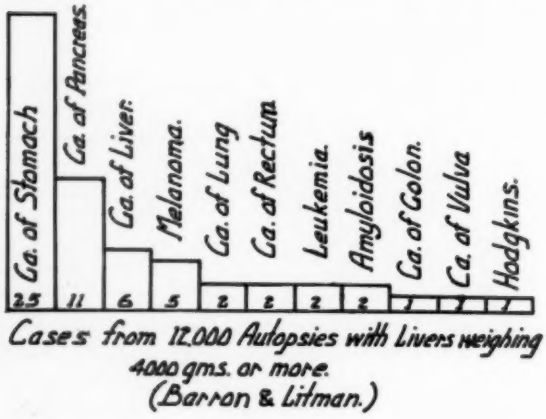


FIG. 2

Hodgkin's disease must also be considered as causes of moderate enlargement. A large number of other conditions, however, produce some hepatomegaly but are never accompanied by very large livers.

Two such conditions, namely, cardiac decompensation and acute infections (septicemia, relapsing fever, yellow fever, etc.) will not be considered here because they are both definite contraindications to the use of pneumoperitoneum.

The presence of jaundice is of some value in diagnosis and a moderate hepatomegaly in a patient with icterus suggests the presence of common duct obstruction, hypertrophic (Hanot's) cirrhosis or hemolytic jaundice. Poisoning with such substances as chloroform, phosphorus and arseniureted hydrogen, produce similar changes, but since the patients are too ill for pneumoperitoneum studies they will not be included in this discussion.

Obstruction of the common duct may be produced by gallstones, cholangitis or other diseases of the duct, external pressure by tumors, glands or adhesions and diseases in the pancreas, especially carcinoma of the head. In the latter condition the gallbladder is markedly enlarged but the other diseases may produce little or no enlargement. This is especially true when the blockage occurs in the portal fissure from external pressure. These patients have large amounts of bile in the urine and bulky, offensive, clay-colored stools. The spleen shows no enlargement.

Hypertrophic biliary cirrhosis produces a large liver weighing from 2,500 to 3,800 gm. which may be adherent to the diaphragm. The spleen is also definitely enlarged and it may be surrounded by adhesions. Although the urine contains bile, the stools are not clay-colored as in obstructive jaundice.

Hemolytic jaundice is accompanied by a very slight enlargement of the liver, or none at all, but the spleen is definitely enlarged. The urine does not contain bile

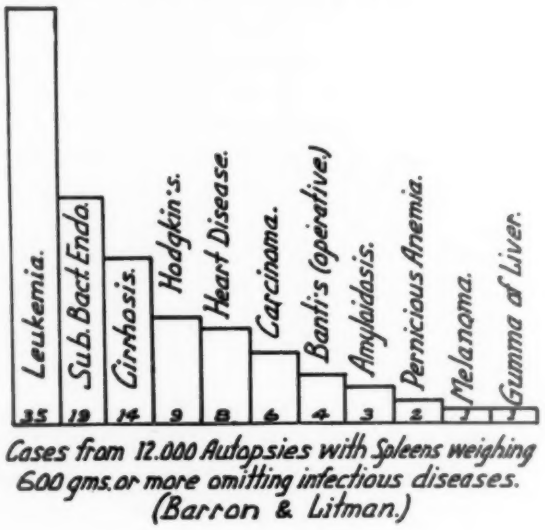


FIG. 3

and the stools are not clay-colored. Certain laboratory tests such as the detection of abnormal fragility of the red cells are of value in the diagnosis. For some unknown reason a positive Wassermann reaction is sometimes present, with no demonstrable evidence of syphilis.

Some of the blood diseases such as pernicious anemia, polycythemia, leukemia and sickle cell anemia give rise to moderate enlargements of the liver but the laboratory

findings render roentgenographic studies unnecessary. Splenic anemia might also be placed in this group but it will be discussed under the heading of splenomegaly.

Some chronic infections may be safely studied following the introduction of gas into the peritoneal cavity. Tuberculosis of the liver is likely to follow extensive involvement of other parts of the body, the detection of which makes the cause of the hepatomegaly evident. Miliary involvement causes a smooth generalized enlargement of the liver, although a surrounding peritonitis may accompany the appearance of lesions in the capsule.

Rarely a large tuberculoma appears in the liver. When it reaches the surface it may be demonstrated in pneumoperitoneum films. When these masses break down a subphrenic abscess usually results.

The changes due to syphilis are somewhat different in the congenital and acquired types. In the former, both the liver and the spleen show considerable enlargement and at times they are both surrounded by adhesions which may be demonstrated following pneumoperitoneum. Acute or secondary syphilis of the acquired type produces slight enlargement of the liver and spleen but they require no roentgen studies. In the tertiary stage of the disease, the liver may be definitely enlarged by gumma formation, which at times gives the organ an irregular outline. The replacement of the gummata by cicatrices produces a marked deformity which can be readily demonstrated after gas is introduced into the abdominal cavity. Unfortunately, the hepatic changes in such cases may be due partly to amyloidosis and partly to fibrosis, which conditions cannot be differentiated roentgenographically. Since the liver changes in lues are in no way diagnostic, much dependence must be placed on the history, physical signs and the Wassermann test.

Other chronic infectious processes such as amebiasis and actinomycosis produce abscesses of sufficient size to bring about a definite hepatomegaly. When these processes reach the surface of the organ, subphrenic abscesses are frequently followed by the formation of adhesions and at times the process ruptures through the diaphragm into the right lung. A history of pain accompanied by chills, fever and leukocytosis indicates the presence of an abscess in an enlarged liver but the preoperative detection of the causative organism is not always easy. Enlargement of the right lobe of the liver favors abscess, and elevation and fixation of the right diaphragm point to a subphrenic infection.

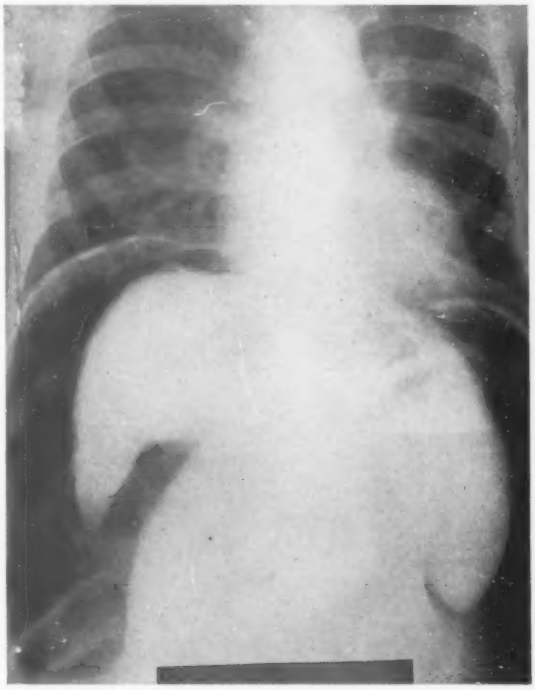


Fig. 4. Pneumoperitoneum film showing the shrunken hobnail liver and large smooth spleen of atrophic cirrhosis.

Certain metabolic disorders are accompanied by hepatic enlargement. Some of them are so poorly understood that they will be omitted here. Patients with diabetes mellitus have a moderate smooth enlargement of the liver which requires no roentgen study, but in bronze diabetes there is a more marked hepatomegaly with a cirrhosis which may produce the first noticeable symptoms. The skin pigmentation is frequently not noticed by the victim, but

its detection together with the discovery of a glycosuria makes the diagnosis. When a large cirrhotic liver is demonstrated in a patient showing an intensified pigmentation about the genitalia and nipples and over the forehead, face, backs of the hands and forearms and the lower extremities, this condition should be suspected.

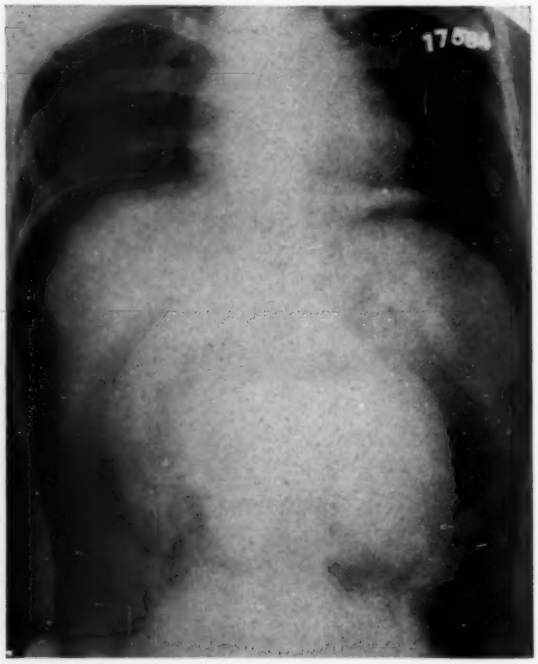


FIG. 5. Smooth liver of normal size and large smooth spleen with marked anemia in a case of splenic anemia.

Gaucher's disease is rather rare but since the liver and the spleen are both enlarged in this condition, it should be discussed here. The onset is insidious and often occurs in childhood. The abdomen eventually shows marked enlargement because of the splenomegaly and hepatomegaly. The exposed portions of the skin take on a brown pigmentation, and hemorrhage from the various body orifices is not uncommon. A curious feature of the disease is the formation of yellow triangular thickened areas in the conjunctiva on either side of the cornea simulating pingueculae. The bones often show medullary absorption and cortical thinning, giving place later to new bone formation which produces a mottled appearance in the roentgenogram. Spontaneous fractures have been observed in the diseased bones. A positive diagnosis is made when the characteristic Gaucher cell is discovered in material obtained by a bone marrow or splenic puncture.

Niemann-Pick's disease is very similar in its clinical characteristics to Gaucher's disease. It is insidious in onset and is limited to infants, none of the victims having survived the second year of life. Both the liver and the spleen are markedly enlarged and the bones show an osteoporosis. The diagnosis is made by finding Niemann-Pick's cells in material obtained from the bone marrow, spleen or lymph nodes.

A smooth uncomplicated hepatomegaly is sometimes produced by the storage of fat or by fatty degeneration and is called a fatty liver. Such changes are likely to accompany tuberculosis, pernicious anemia, alcoholism, cyclic vomiting, etc., and the diagnosis can only be inferred when an enlarged liver is discovered.

Uncomplicated hepatic enlargement is also at times due to the presence of cysts or benign tumors. Cysts may be produced by parasites or by obstruction of the bile ducts or may have no apparent cause. It is not unusual to find one or more such lesions in the liver when the patient has polycystic kidneys. Benign tumors are usually adenomas or angiomas and may be single or multiple. The presence of these lesions cannot be suspected from the roentgenograms except when they grow on or near the surface of the enlarged liver. A peculiar downward tongue-like projection from the under surface of the liver known as Riedel's lobe occurs rarely, but the only case in which such a diagnosis was made in our laboratory proved at operation to have a huge gallbladder filled with stones which produced the tongue-like shadow in the roentgenogram.

THE VERY LARGE SPLEEN

Barron and Litman in their study of 12,000 autopsies found 102 spleens weighing 600 gm. or more in individuals dying

of noninfectious diseases. Of these 102 cases, 35 had leukemia; 19 subacute bacterial endocarditis; 14 cirrhosis of the liver; 9 Hodgkin's disease; 8 heart disease; 6 carcinoma; 4 Banti's disease; 3 amyloidosis; 2 pernicious anemia; 1 melanoma, and 1 gumma of the liver. Since cardiac disease and acute infections contraindicate the injection of gas into the peritoneal cavity, these figures make it evident that a large spleen portrayed by pneumoperitoneum points to leukemia, subacute bacterial endocarditis, cirrhosis of the liver and Hodgkin's disease as the most likely diagnoses. In the southern portion of the United States chronic malaria should be added to this list. Leukemia can be diagnosed by blood studies and subacute bacterial endocarditis by a febrile history and a positive blood culture. This latter condition often produces extreme enlargement of the spleen. Even if a blood stream infection is present the intraperitoneal use of carbon dioxide has, in my experience, produced no ill effects. When peripheral adenopathy is present, Hodgkin's disease can be detected by a biopsy, but when the lesions are all within the abdomen, or as occasionally happens, limited to the spleen, a relapsing fever may be the only suggestive finding. In atrophic cirrhosis the small hobnail liver is diagnostic, but when the cirrhotic liver is enlarged the diagnosis can only be arrived at by elimination and inference. The detection of a large smooth spleen and a normal liver in a patient who has a long history of chills and fever points to malaria as the most likely etiological factor.

Carcinomatosis is occasionally accompanied by a very large spleen. Although metastases have on a few occasions been discovered in this organ, the enlargement is usually due to congestion secondary to pressure on the splenic vein by masses of malignant lymph nodes.

The diagnosis of splenic anemia is inferred in patients with a chronic splenogaly and a marked secondary anemia. As the disease progresses, cirrhosis of the liver appears; and the patient is said to have Banti's disease when the roentgen findings of atrophic cirrhosis are accompanied by a marked secondary anemia. In the late stages of this condition, ascites and a thrombophlebitis and thrombosis of the portal vein may be present.

A smooth enlargement of both the liver and spleen in a patient who has suffered

Fig. 6. Huge gallbladder containing over 1,100 stones incorrectly diagnosed as a Riedel's lobe of the liver before operation.

from some chronic suppurative process over a long period of time suggests the presence of amyloidosis. This condition often accompanies the suppurative forms of syphilis and tuberculosis. Amyloid has the power of rapidly removing Congo red from the blood, and the determination of the rate of disappearance of this dye from the blood stream following its intravenous injection is of some diagnostic value.

In pernicious anemia the spleen is usually just palpable, but occasionally it reaches a great size. Careful blood examination should of course make pneumoperitoneum unnecessary in such anemic individuals.

Melanoma of the spleen can be diagnosed only when external evidence of the disease is discovered. Gummatous enlargements will be discussed later under the heading of syphilitic splenomegaly.

MODERATE SPLENIC ENLARGEMENT

A large number of the blood dyscrasias produce more or less splenic enlargement.

Fig. 7. Smooth, moderately enlarged liver and huge smooth spleen in a case of subacute bacterial endocarditis proved by autopsy.

Hemolytic icterus is accompanied by a rather marked splenomegaly. It is diagnosed by a history of long-continued acholuric jaundice, hemolytic crises, biliary colic and anemia, together with the finding of microcytosis and increased fragility of the erythrocytes. A very moderate splenomegaly often appears in purpura hemorrhagica, polycythemia vera, pernicious anemia, agranulocytic angina and sickle cell anemia. The patient's appearance and the blood studies should identify these diseases and make roentgen studies unnecessary.

Big spleens are usually found in infants with chronic anemia. Von Jaksch, Cooley, and others, have described several different types of anemia in babies, but their classifications are very confusing because similar findings may be produced by rickets, syphilis, Niemann-Pick's disease, Schüller-Christian's syndrome, sickle cell and splenic anemia, all of which occur in infancy. The characteristic roentgen signs in the skull and long bones will in many instances make a study of the intra-abdominal structures unnecessary. Pneumoperitoneum studies are of little value except so far as they rule out conditions in the abdomen outside the liver and spleen.

As has already been pointed out, some of the metabolic disorders produce marked changes in the abdominal structures. In Gaucher's disease both the liver and spleen are enlarged, and the condition comes on slowly with pigmentation of the skin and hemorrhage from the various orifices. The diagnosis is made from microscopic studies of material removed by bone marrow puncture or splenic puncture. The roentgenographic appearance of the bone changes has already been described. Niemann-Pick's disease is limited to infants and it also produces splenomegaly, hepatomegaly and osteoporosis. It can be differentiated positively from Gaucher's disease only by bone marrow or splenic puncture. The diagnosis is important because babies with Niemann-Pick's disease never live beyond the second year, whereas infants with Gaucher's disease may live many years.

Many cases of xanthomatosis show some splenomegaly. When glycosuria and lipemia are present the spleen often reaches a large size. The disease can usually be identified by the characteristic skin lesions, but when they are not typical the microscopic demonstration of foam cells in a biopsy specimen from the skin removes all doubt. Although Schüller-Christian's disease is a form of xanthomatosis, enlargements of the liver and spleen are seldom mentioned in the histories of reported cases. In a very few instances the lower edges of these organs have been reported

as reaching the level of the umbilicus.

The changes in the liver found with the hemachromatosis of bronze diabetes have already been described. The spleen shows very little change at first but as the liver becomes cirrhotic, definite splenomegaly appears and it may be accompanied by a perisplenitis. When the roentgen signs of cirrhosis of the liver are accompanied by pigmentation of the skin and diabetes, the diagnosis is made.

It may be mentioned in passing that splenomegaly is not uncommon in scurvy and rickets. The typical physical findings and roentgen studies of the bones should, of course, render roentgenologic investigation of the abdomen unnecessary.

Circulatory pathology is at times responsible for changes in the spleen. Endophlebitis and thrombosis of the portal and splenic veins may occur in repeated attacks with the gradual appearance of splenomegaly. The exact nature of these attacks is usually not recognized clinically, but the discovery of an enlarged spleen in a patient with such a history should arouse the examiner's suspicions. The disease known as chronic hyperplastic polyserositis or Concato-Pick's disease may not be, strictly speaking, a circulatory disorder, but it is often so classified. It is a chronic condition in which perihepatitis, perisplenitis and pericarditis are accompanied by ascites and pericardial effusion. In some instances a similar process appears in the pleural cavities. The spleen may be moderately enlarged. Pneumoperitoneum studies done following the removal of the ascitic fluid reveal the adhesions about the liver and spleen and in the pleural cavity and also the enlargement of the pericardial sac. These findings together with the chronic history usually make the diagnosis. An aneurysm of the splenic artery is a very rare lesion which may produce some degree of splenomegaly. It should be suspected when a thrill or bruit is discovered in the upper abdomen of a patient with recurrent attacks of pain.

Splenomegaly can often be blamed on chronic infections. A tuberculous splenitis which eventually produces a very large organ is frequently accompanied by a tuberculous peritonitis. When the roentgenogram reveals an enlarged spleen containing calcified areas and surrounded by adhesions this disease is usually present. The ring-like shadows produced by phleboliths in the spleen must not be mistaken for calcified tubercles.

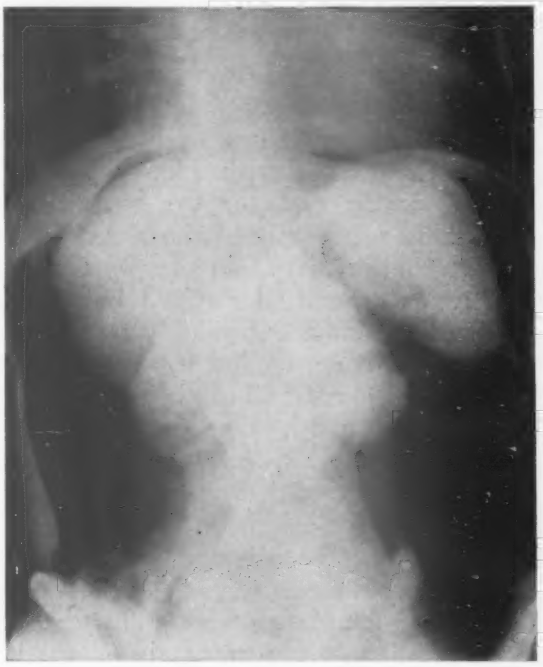


Fig. 8. Adhesions about liver and spleen and marked enlargement of pericardial sac in a case of polyserositis (Concato-Pick's disease).

Syphilis may also be accompanied by a very large spleen but fortunately the Wassermann test is usually strongly positive with this visceral manifestation of the disease. For some unknown reason hemolytic icterus may also give a strongly positive Wassermann test and its presence must always be ruled out. The hepatic pathology which is likely to be found with splenic enlargement in syphilis has already been described.

Giffen[3] thinks that one type of chronic splenomegaly is due to some of the more common infections and may be found with

arthritis, tonsillitis, furunculosis, phlebitis, ulcerative colitis, etc. Although a marked anemia is found with this condition, Giffen feels that it should not be called splenic anemia because improvement does not follow splenectomy. Some of the tropical diseases such as kala-azar, bilharziasis, and sleeping sickness also produce splenomegaly but the diagnosis can only be made through the detection of the etiological factors.

An uncomplicated enlargement of the spleen may be produced by cysts or benign tumors. Echinococcus infection and polycystic disease with kidney involvement produce cysts of the spleen, and cysts are occasionally of the hemorrhagic or dermoid variety. Primary sarcomas sometimes arise in the spleen but metastatic carcinoma is exceedingly rare in this location. Primary benign tumors, usually angiomas or fibromas, have been described. These lesions can be demonstrated roentgenologically only when they are situated near the surface of the organ.

Splenomegaly and hepatomegaly occur in a group of rare diseases about which very little is known. Only one of these conditions, namely, marble bone disease (Albers-Schönberg's syndrome) is of special interest to roentgenologists. Theoretically, splenomegaly appears in this disease when anemia is produced by a reduction in the volume of the bone marrow secondary to the excessive deposition of lime salts. Usually the diagnosis becomes evident when roentgen studies of the bones are available.

DISCUSSION

From the above material, certain facts become evident. The demonstration of the shrunken liver with the determination of the cause of the shrinkage constitutes one of the most important uses of pneumoperitoneum. The discovery of a very large liver almost invariably indicates the presence of malignancy, especially when the spleen is of normal size, and the primary growth is almost always located somewhere in or near the gastrointestinal tract. Occasionally extreme hepatic enlargement is due to melanoma, leukemia, Hodgkin's disease or amyloidosis.

When the liver is moderately enlarged and chronic jaundice is present, the most likely diagnoses are common duct obstruction, chronic biliary cirrhosis and hemolytic jaundice. These conditions are easily differentiated from the history and laboratory findings. In most of the blood diseases, chronic infections and metabolic disorders accompanied by hepatomegaly, pneumoperitoneum is not indicated because a diagnosis can be made from the clinical and laboratory findings alone.

When an unusually large spleen is demonstrated, leukemia, subacute bacterial endocarditis, cirrhosis of the liver and Hodgkin's disease are the most likely diagnoses, but malaria, splenic anemia, carcinomatosis, amyloidosis, melanoma and gumma must be considered.

A moderate enlargement of the spleen accompanies such blood dyscrasias as hemolytic icterus, purpura hemorrhagica, polycythemia vera, pernicious anemia, agranulocytic angina, sickle cell anemia and the anemias of infancy, all of which should be diagnosed from the clinical laboratory findings alone.

Such metabolic disorders as Niemann-Pick's disease, Gaucher's disease and xanthomatosis produce a splenomegaly, but histological studies reveal the underlying pathological changes. The roentgenographic demonstration of cirrhosis of the liver and its accompanying splenic enlargement is sometimes of value in the diagnosis of bronze diabetes.

Many of the changes observed with Concato-Pick's disease are revealed by pneumoperitoneum studies but no helpful information is forthcoming when splenomegaly results from endophlebitis and thrombosis of the portal vein.

Calcifications in a large spleen suggest the presence of tuberculosis but roentgen investigation is of no specific value in diagnosing other chronic infectious spleno-

megalias of which there are many. The presence of tumors and cysts may be inferred when rounded projections are seen on the surface of the organ.

In some of the rare diseases such as marble bones the splenomegaly is easily explained from the clinical and roentgenologic studies.

SUMMARY

1. Pneumoperitoneum constitutes a valuable method for determining the size and identity of solid soft tissue structures in the upper abdomen.

2. When the method is combined with other clinical procedures, it is often helpful in diagnosing many of the chronic disorders which cause changes in the liver and spleen.

REFERENCES

1. Alvarez, W. C. Use of CO_2 in pneumoperitoneum. Am. J. Roentgenol., 1921, *8*, 71–72.
2. Barron, M., and Litman, A. B. Importance of hepatomegaly and splenomegaly in differential diagnosis. *Arch. Int. Med.*, 1932, *50*, 240–256.
3. Giffen, H. Z. Diseases of the Spleen. Oxford Medicine, Vol. IV, Chap. III., p. 78 (1).
4. Martin, C. L. Pneumoperitoneum. *Texas State J. Med.*, 1922, *17*, 577–579.
5. Pfahler, G. E. Measurement of the liver by means of roentgen rays based on a study of 502 subjects. Am. J. Roentgenol. & Rad. Therapy, 1926, *16*, 558–564.
6. Radt, P. Eine Methode zur röntgenologischen Kontrastdarstellung von Milz und Leber. *Klin. Wchnschr.*, 1929, *8*, 2128–2129.
7. Rolleston, H. Diseases of the Liver. Oxford Medicine, Vol. III, Part 1, p. 410.
8. Stewart, W. H., and Stein, A. Roentgen ray study of the abdominal organs following oxygen inflation of the peritoneal cavity. Am. J. Roentgenol., 1919, *6*, 533–542.
9. Yater, W. M., and Otell, L. S. Differential diagnosis of diseases of the liver and spleen by the aid of roentgenography after the intravenous injection of thorotrast. Am. J. Roentgenol. & Rad. Therapy, 1933, *29*, 172–181.

DISCUSSION

Dr. Arthur W. Erskine, Cedar Rapids, Iowa. Dr. Martin has made an exhaustive study of a rather neglected subject. He has left little for me to do in the way of addition or subtraction. However, one might again mention the fact that the intravenous use of thorium dioxide is not without its danger, and question the widsom of some advertising matter in which it seems to be regarded as entirely harmless. There is need for a study of the limits of variation in the size of normal spleens and the relation of the size of the spleen to the size, weight and habitus of the normal individual.

In addition to the value of pneumoperitoneum in demonstrating lesions of organs themselves, it is obviously equally valuable conversely; that is, by differentiating palpable masses in the upper abdomen from the liver, spleen and kidney.

Finally, if one can routinely show a small liver by the methods Dr. Martin has described in his paper, their usefulness in the diagnosis of atrophic cirrhosis must be apparent.

ROENTGEN PELVIMETRY AND FETOMETRY*

By PAUL C. HODGES, M.D.
CHICAGO, ILLINOIS

IN AN earlier publication[9] the development of roentgen pelvimetry up to 1932 was reviewed, and later in the same year[14] certain phases of fetometry were described. Since that time, though advances have been made in both these fields and obstetricians as a class increasingly have come to appreciate the importance of roentgen examinations of the pelvis and the fetus, no single method has been accepted as standard and there remains difference of opinion as to what information should be sought, to say nothing of the technical means of seeking it.

The present paper reviews some of the more recent publications in this field and presents certain work from our laboratory heretofore unpublished. In presenting a little that is new it has, of course, been necessary to refer to much that is old and well established.

CLASSIFICATION OF PELVES

Until recently, most of the workers employing roentgen rays in the study of dystocia used them principally as a substitute for calipers in measuring one or more of the diameters of the pelvic inlet. Such use is undoubtedly important but the most important single recent development in this field is the growing recognition of the usefulness of a thoroughgoing qualitative survey of the pelvis as a whole, with or without quantitative estimates of certain of its diameters. Caldwell and Moloy[2] point out that typical male (Fig. 1) and female (Fig. 2) pelves show the following distinguishing sexual characteristics (Table 1).

VARIATIONS IN FEMALE PELVES

Female pelves may show one or more male characteristics and occasionally di-

TABLE I

Part		Typical Male Pelvis	Gynecoid Type Female Pelvis
Inlet as a whole		Heart shaped	Round
Anterior segment		Triangular	Rounded
Posterior segment		Shallow	Deep
Pubic symphysis		Bulging	Flat
Sacrum	Body	Narrow	Wide
	Inclination	Straight and forward	Curved and backward
	Promontory	Bulging	Flat
Sciatic notch		Narrow	Broad
Vertical height		Great	Small
Pubic rami		Long and straight	Short and curved
Bi-spinous diameter		Small	Great

* From the Division of Roentgenology, The University of Chicago. Read at the Thirty-seventh Annual Meeting, American Roentgen Ray Society, Cleveland, Ohio, Sept. 29–Oct. 2, 1936.

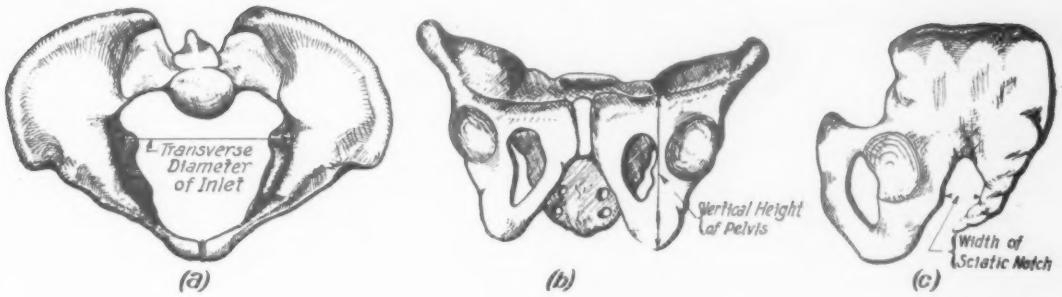


Fig. 1. Average male pelvis

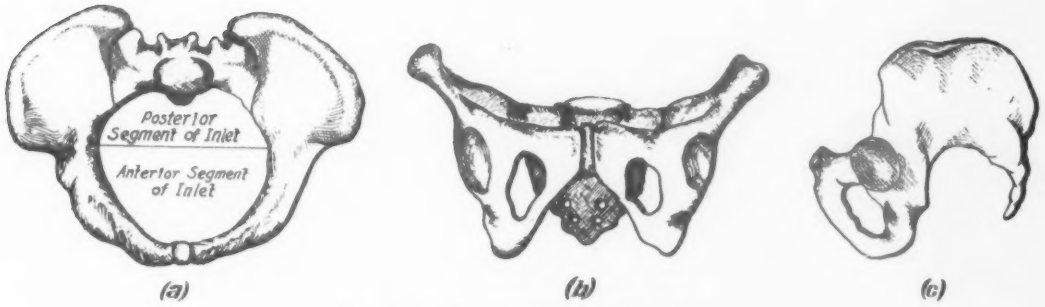


Fig. 2. Gynecoid type female pelvis

vergence from the normal may be so great that sex cannot be determined from inspection of the pelvic bones alone. The size and shape of that portion of the inlet lying behind the greatest transverse diameter are of particular significance in obstetrics because an ample dimension of this posterior segment may allow delivery of a full-sized fetal head in spite of diminished size in other parts, whereas an inadequate posterior segment is almost certain to interfere with delivery of a fetus even though the pelvis be adequate in other respects.

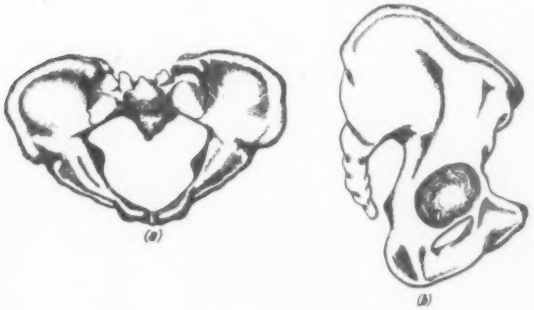


Fig. 3. Android type female pelvis.

Basing their classification on the condition of the posterior segment of the inlet, these authors divide female pelves into four types: the typical female or gynecoid type (Fig. 2), the male-like or android type (Fig. 3), the anthropoid type (Fig. 4), and the flat type (Fig. 5). Findings in other parts of the pelvis (Table II) are described as conforming to or diverging from the general type established by the condition of the posterior segment of the inlet.

Fig. 4. Anthropoid type female pelvis.

Any sort of outlet may occur in any type of pelvis, so a given female pelvis classified on the basis of its posterior segment

as gynecoid, android, anthropoid or flat may be further classified as being large, medium or small with wide, medium or narrow outlet.

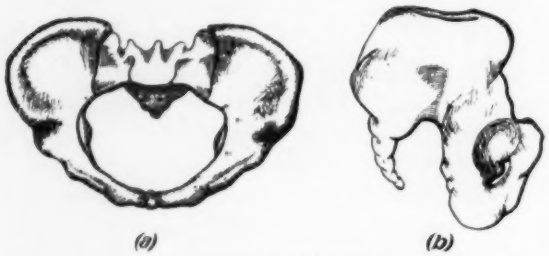


FIG. 5. Flat type female pelvis.

A small android type pelvis with narrow outlet is the severe grade "funnel pelvis" of other classifications.

The 6 female pelves in Figure 6 exhibit considerable variation in straightness or curvature of the pubic rami, point of origin of rami relative to the pubis, width of subpubic angle, width of sacrum and height of pelvis. (*a*), (*b*), and (*c*) illustrate respectively narrow, moderate and wide forms of the female type of outlet. In all 3 the pubic rami are relatively short, rise at the lateral margins of the undersurface of the symphysis and curve outward in their downward course. In all 3 also there is a relatively wide subpubic angle, a wide sacrum and a short vertical height. (*d*), (*e*), and (*f*) illustrate respectively nar-

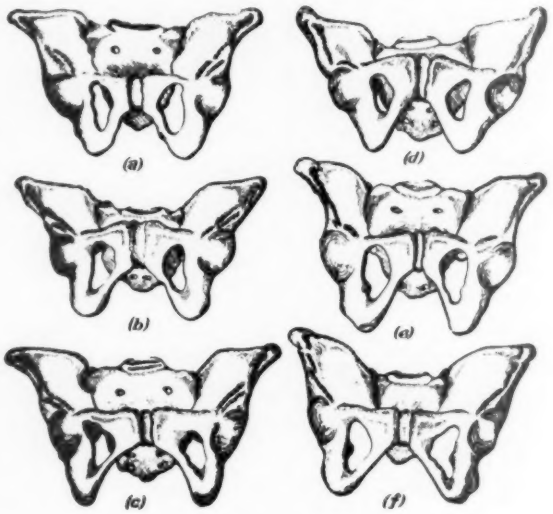


FIG. 6.

TABLE II

Part		Gynecoid	Android	Anthropoid	Flat
Inlet		Round	Heart shaped	Long and narrow	Short and broad
Anterior segment		Rounded	Triangular	Triangular	Rounded
Posterior segment		Deep	Shallow	Very deep	Relatively normal
Sacrum	Body	Wide	Narrow	Narrow	Gynecoid
	Inclination	Curved backward	Straight forward	Curved backward	
	Promontory	Flat	Bulging	Flat	
Sciatic notch		Narrow	Broad	Broad, high, shallow	Narrow
Measurements		Average of 26 cases	Average of 25 cases	Average of 19 cases	Average of 3 cases
Conjugate diameter of inlet		10.86 cm.	10.59 cm.	11.75 cm.	8.55 cm.
Transverse diameter of inlet		13.76 cm.	13.56 cm.	12.94 cm.	14.45 cm.

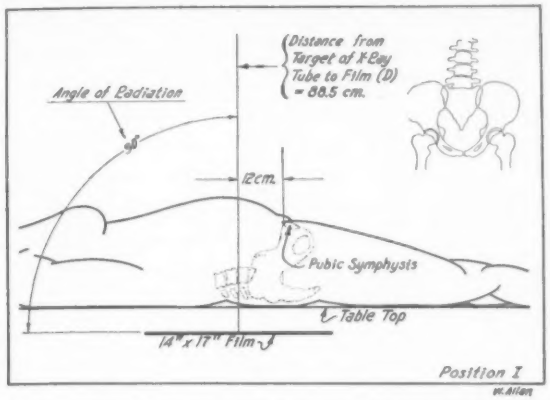


FIG. 7. Position I, frontal view. In the sketch the patient is recumbent but it is sometimes preferable to have her stand back to film. Insert shows tracing from roentgenogram obtained in this position. If examination must be limited to a single roentgenogram, this is the position of choice. It is one of the views employed in 90° triangulation methods.

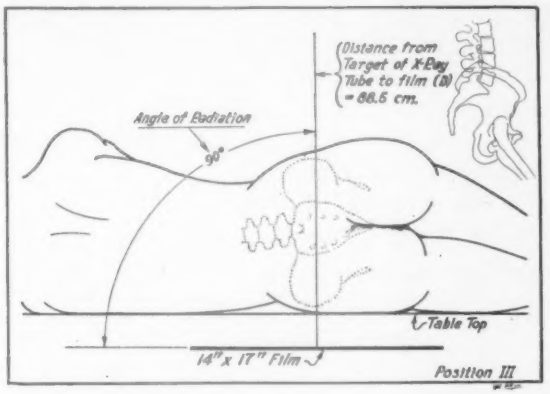


FIG. 9. Position III, lateral view. The subject is shown lying on her side on an exposing table, but it is preferable to have her stand with either the right or left side against the film. This is the position of choice for measurement of conjugata vera and is one of the two views used in 90° triangulation methods. The insert shows a tracing from a roentgenogram obtained in this position.

row, moderate and wide forms of the male type of outlet as it occurs in the female pelvis. The rami are long and straight, arise from the undersurface of the symphysis and produce a small "angular" subpubic angle. Vertical height is increased.

MULTIPLE STEREOSCOPIC VIEWS

In those cases in which it is economically possible to make stereoroentgenograms in three and preferably four positions (Figs. 7, 8, 9, and 10), the roentgenologist who has familiarized himself with Caldwell and Moloy's classification should be able to supply the obstetrician with a reliable prediction as to the general obstetrical adequacy of a particular pelvis.

Furthermore, if the pelvis contains a fetus of over twenty weeks' development such a set of roentgenograms makes possible a statement as to its condition and position and by techniques presently to be described allows an estimate of its size and

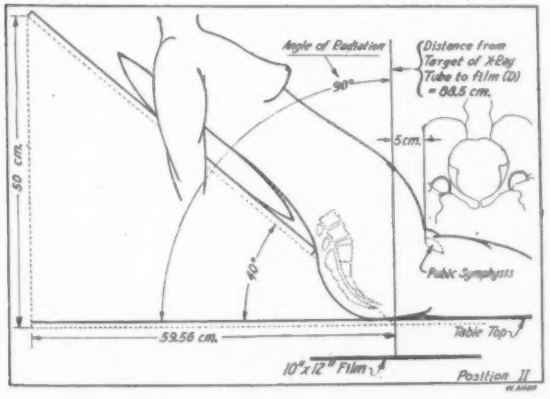


FIG. 8. Position II, inlet view. With the patient in this semi-recumbent position, the roentgenogram obtained (see insert) gives the best possible view of the inlet. On the other hand, it supplies little conception of the condition of the subpubic arch and other portions of the pelvis.

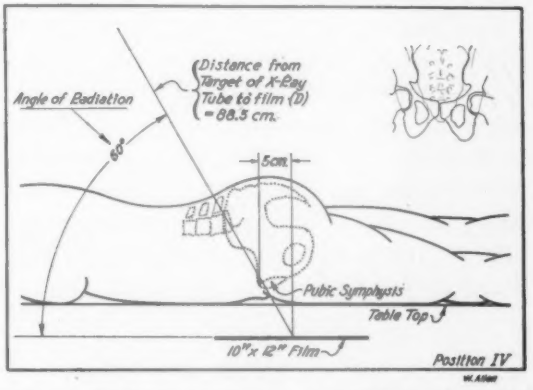


FIG. 10. Position IV, outlet view. Under favorable conditions this view allows excellent visualization of the subpubic arch, a point of importance in the qualitative classification of a pelvis. It is of no value in studying the inlet.

probable age. Finally, these thoroughgoing evaluations of fetus and pelvis constitute the best sort of evidence on which to base an opinion as to the ability of a particular fetus to be delivered through a particular birth canal.

With very slight modification, the general purpose apparatus available in any good roentgen laboratory suffices for the making of such a set of stereoroentgenograms, and the additional instruments required for quantitative work-up of the films need not be complicated or expensive. There are, of couse, many cases in which extensive filming of this sort is economically impossible and for these there have been developed reasonably satisfactory short-cut methods that are described elsewhere in this paper.

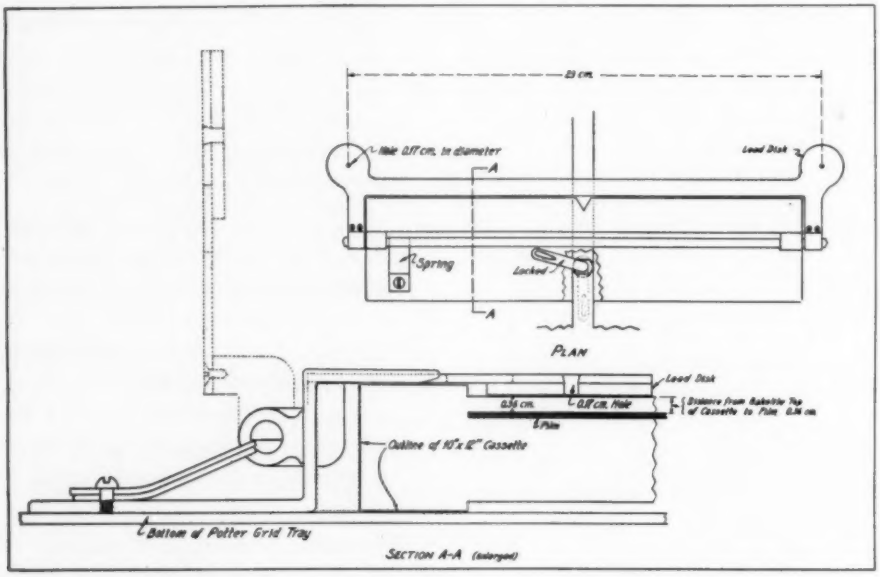


FIG. 11. Register device. The small holes in the lead disks photograph at the edge of the film as tiny black points approximately 23.15 cm. apart. A line drawn on the film connecting these points is parallel with the optical axis of the film and distant from it by an amount varying with the size and position of the skull (see Table III and Fig. 12).

MENSURATION FROM STEREOROENTGENOGRAMS

Regardless of how stereoroentgenograms are made, their images are more or less distorted, and allowance for this distortion must be made if measurements are to be valid. Essential steps in the procedure are the establishment of fixed and known target-film distance and tube shift (D and K of Equation (2)) and the provision of some sort of film-register device (Fig. 11).

The optical axes of stereoroentgenograms are imaginary lines formed by connecting the foot points of imaginary perpendiculars dropped to the films from the two ends of the line of tube shift (K). Precise registration of axes is necessary when films are superimposed for measurement of parallax, are placed on the viewboxes of a measuring stereoscope preliminary to making direct measurements of the stereoscopic image, or are measured with a stereoroentgenometer.

If it were possible to design roentgen apparatus so that the geometric axes of the two films occupied exactly the same position in space relative to the line of tube shift (K), the registration of these geometric axes would suffice. Actually, however, cassettes are always somewhat larger than the nominal sizes of the films they are designed to hold and so the optical

axes of stereoroentgenograms are seldom identical with their geometric axes. For quantitative work it is necessary, therefore, to provide a graphic guide that will indicate the optical axis regardless of slight variation in the size of the film or its exact location within the cassette at the time the exposure was made.

The particular register device illustrated here (Fig. 11) shows in completed roentgenograms as two small black dots at the centers of clear buttons lying along the edges of the films. A line drawn to connect these dots is parallel with the optical axis of the film, and a perpendicular bisector of this line is a perpendicular bisector also of the axis. The perpendicular distance between axis and register points varies with the size and position of the film (Table III).

TABLE III

Film Size	Perpendicular Distance between Register Points and Stereoscopic Axis	
14″×17″	20.5 cm.	16.8 cm.
10″×12″	14.3 cm.	11.8 cm.
Long axis	Crosswise	Lengthwise

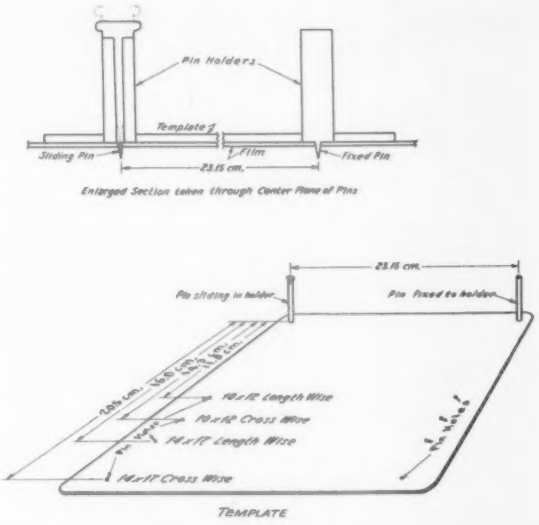


FIG. 12. Template used for locating optical axes of stereoroentgenograms or 90° triangulation roentgenograms by means of register points. With the film tacked down to a drawing board, the fixed pin is inserted at the center of the upper register point; the upper hole of the template is now fitted over this pin and with the pin as a pivot the plate is manipulated until the center of its lower hole corresponds as nearly as possible with the center of the lower register point. The holder for the sliding pin is now inserted through the lower hole and with this as a guide the sliding pin is pressed through the lower register point into the drawing board. Pin pricks through the appropriate pin holes in the body of the plate now provide landmarks for drawing in the optical axis.

REGISTER HOLES

Using a needle-pointed stylet, small holes are pricked through the films at the sites of their register points, their optical axes are located by means of a template (Fig. 12), and then with the prick marks as centers 5 mm. diameter register holes are punched out. Stereoscopic films thus prepared and superimposed on a viewbox with their register holes coinciding have coincident axes and are in position for measurement of parallax. Placed on a stereoroentgenometer with their register holes over the register studs, their axes coincide with the axis of the roentgenometer and they are in position for measurement by that instrument. Placed on the viewboxes of a measuring stereoscope with the register holes over the register studs, the virtual image produced by the half-surfaced mirrors reproduces faithfully the size and shape of the object shown in the roentgenograms.

THE MEASURING STEREOSCOPE

Caldwell and Moloy have stimulated production of an American instrument similar to the one developed by Pulfrich[12] in 1909 which had grown out of the work of the Canadian geographer Deville[6] in 1902, and subsequent developments by Hasselwander[7] and Trendelenburg[16] in 1915. In all these instruments the essential feature is the production of a faithful virtual image of the object under examination and the simultaneous observation of that image and of an independently illuminated ruling device placed within it.

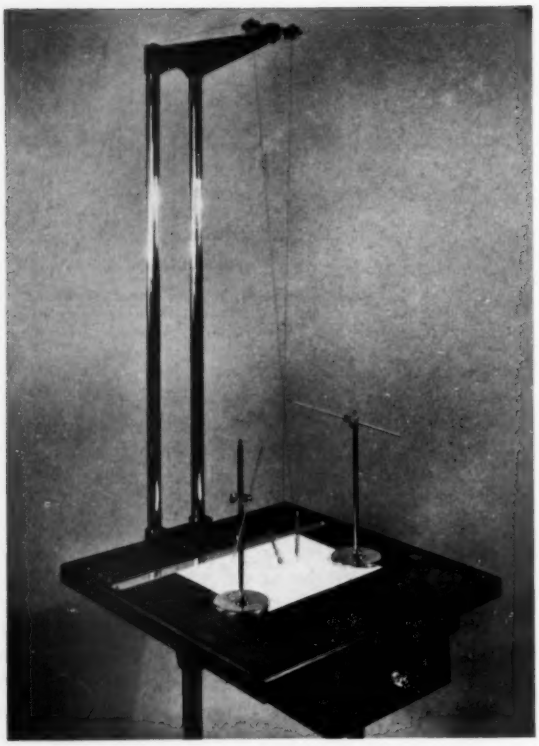


FIG. 13. Stereoroentgenometer. With this particular instrument shadow points are transferred from stereoroentgenograms to paper which is then pinned to a cork-covered bed. The threads which reconstruct the path followed by the rays from target through object to film are anchored into the shadow points on the paper by means of sewing-machine needles plunged into the cork bed.

Various types of half-surfaced or semi-transparent mirrors have been developed for this simultaneous viewing of ruler and image, and the faithfulness of the image depends upon the care with which target-film distance, film-mirror-eye distance, tube shift, interpupillary distance, line of sight, and film register points are adjusted to one another.

As in all parallax methods, accuracy of measurement is independent of the position of the patient, provided the points being measured are clearly seen. On the other hand, as in roentgenography of all sorts, position is of extreme importance in providing adequate visualization of anatomic structures.

THE STEREOROENTGENOMETER

Davidson,[5] Manges,[11] Chamberlain and Newell,[3] Clifford,[4] and many others, have employed for the construction of three-dimensional, true-size geometric models of objects portrayed in roentgenograms, a type of apparatus to which Johnson[10] has given the name "stereoroentgenometer." In contrast to some of the earlier models, the instrument illustrated here (Fig. 13) substitutes a cork-covered bed for glass-surfaced viewing boxes, uses drawing paper rather than the films themselves as the surface from which the model is built

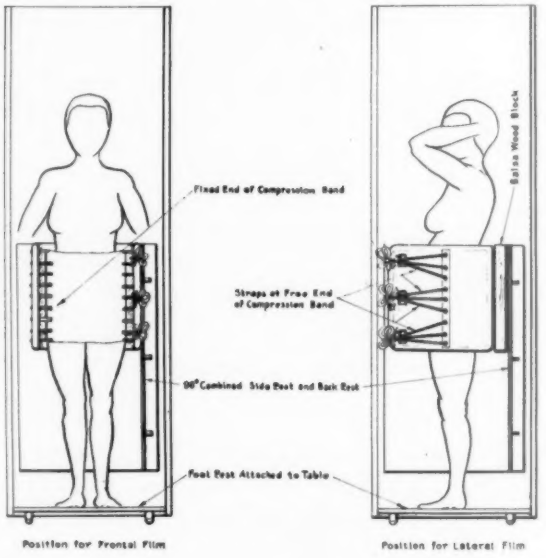

Fixed End of Compression Band
Straps at Free End of Compression Band
90° Combined Side Rest and Back Rest
Foot Rest Attached to Table
Balsa Wood Block
Position for Frontal Film
Position for Lateral Film

FIG. 14. Patient with jacket attached. Though bulky in appearance the jacket is extremely light, is quickly applied and causes the patient little inconvenience. The standing patient slips the jacket on from behind and then stands on the foot rest of a tilting roentgenoscope. When she has been tilted back into the horizontal position a mark is made on the skin of the abdomen 12 cm. above the pubic symphysis and the jacket is shifted up or down, right or left, until the sides of the abdomen are approximately equidistant from the sides of the jacket and the center line painted on the jacket lines up with the 12 cm. skin mark. Pillows are now stuffed in at either side of the jacket and the compression band is cinched up tight, fixing the patient securely within the jacket. The fixed end of the compression band is removed only for laundering and it takes only a few moments to lace and tie the tapes at the free end.

up, provides register studs for centering films on the bed preliminary to transferring shadow points onto the paper, and introduces the use of sewing-machine needles for rapidly and securely anchoring the threads to the shadow points. Theoretically, the stereoroentgenometer, like the measuring stereoscope, can be used for the measurement of any pelvic or fetal part discernible in a pair of stereoroentgenograms. Practically, however, it is better suited to those structures with sharply defined end-points such as the diameters of the pelvic inlet and the interspinous diameter and is less well adapted for measurements of the fetal skull where the end-points are curved lines frequently of different shape in the two films.

GRAPHS FOR CORRECTION OF TRIANGULAR DISTORTION

If a flat or linear object of unknown dimensions lies parallel with the plane of a film and at a known distance above it, its

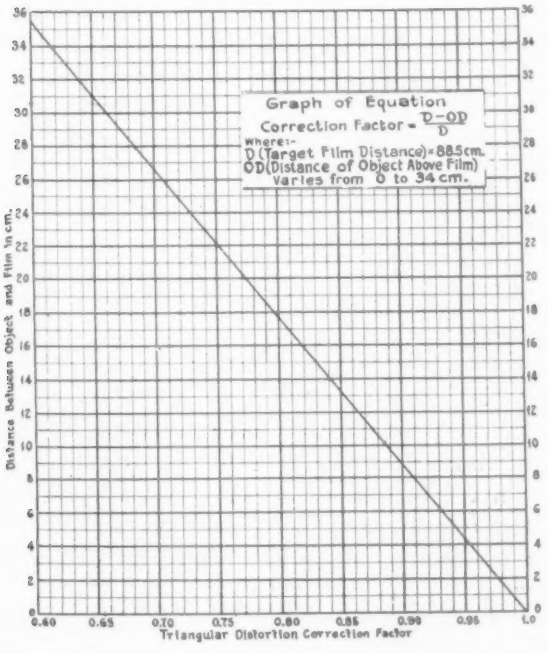

Graph of Equation
Correction Factor = D−OD / D
where:-
D (Target Film Distance) = 88.5cm.
OD (Distance of Object Above Film) Varies from 0 to 34 cm.
Distance Between Object and Film in cm.
Triangular Distortion Correction Factor

Fig. 15. Graph for computation of triangular distortion correction factor where *O.D.* is known or can be calculated as in position methods and 90° triangulation methods.

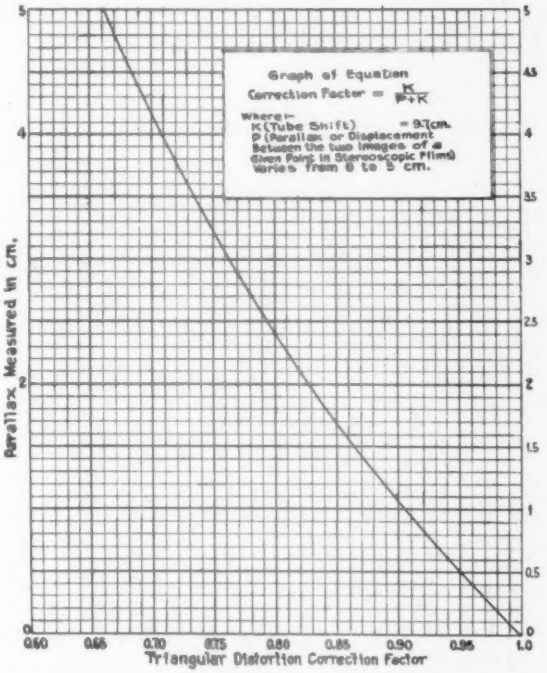

Graph of Equation
Correction Factor = K / P+K
where:-
K (Tube Shift) = 9.7cm.
P (Parallax or Displacement Between the two Images of a Given Point in Stereoscopic Films) Varies from 0 to 5 cm.
Parallax Measured in cm.
Triangular Distortion Correction Factor

Fig. 16. Graph for obtaining triangular distortion correction factor from stereoroentgenograms by means of measured parallax.

dimensions can be calculated from measurement of its roentgenographic image provided the location of the target of the roentgen tube relative to the center of the film is known. The calculation consists of multiplying the diameter of the image by a correction factor (F) obtained from:

$$F = \frac{D - O.D.}{D} \qquad (1)$$

where D = distance between target and film in cm.; $O.D.$ = distance between object and film in cm.

If D is constant for the apparatus being used, the equation can be expressed as a graph (Fig. 15). In stereoroentgenograms, $O.D.$ can be computed from:

$$O.D. = \frac{PD}{P+K} \qquad (2)$$

where P = parallax or measured displacement between the two images of the object; K = distance tube was shifted between exposures.

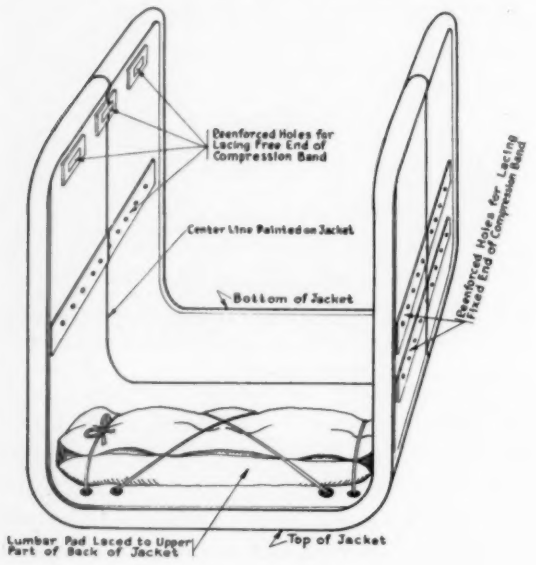
Now by substituting the value of *O. D.* in equation (1) there is obtained:

$$F = \frac{D - \frac{PD}{P+K}}{D}. \qquad (3)$$

Equation (3) may be simplified to read:

$$F = \frac{K}{P+K} \qquad (3a)$$

which expressed as a graph (Fig. 16) allows one to read off the correction factor in terms of parallax.


Reenforced Holes for Lacing Free End of Compression Band
Center Line Painted on Jacket
Bottom of Jacket
Reenforced Holes for Lacing Fixed End of Compression Band
Lumbar Pad Laced to Upper Part of Back of Jacket
Top of Jacket

JACKET

FIG. 17. Details of jacket for 90° triangulation method. The frame is of welded aluminum tubing, the covering stockinet impregnated with celluloid. Reënforced holes are provided for attaining the fixed and free ends of a compression band. With the patient strapped into this jacket the relationship of pelvic and fetal parts to back and sides of jacket remains fixed during the making of both films.

Equation (1) is a mathematical expression of the facts involved in Walton's[17] and Thoms'[15] particular developments of the position method of pelvimetry. Expressed in polar form it appears on the dial of Ball and Marchbanks'[1] pelvicephalometer and, as a rectilinear graph (Fig. 15), it is used in this laboratory in connection with the jacket (Fig. 17).

Equation (3a), as will presently be shown, is in some respects preferable to the stereoroentgenometer for computation of diameters and circumferences of the fetal skull from stereoroentgenograms.

FETOMETRY

A report of the roentgen examination of a fetus should, of course, include a complete qualitative assay of its development and condition as well as of its position relative to the maternal parts. If, in addition, the roentgenologist can supply an estimate of fetal age that does not depend upon the menstrual history, the value of his report is greatly increased. In cases examined late in gestation, if he can report reliably on the relative sizes of fetal skull and birth canal, his contribution may be of the greatest clinical importance.

ROENTGEN ESTIMATION OF FETAL SIZE AND AGE

With a little practice, one becomes able to make a rough estimate of the age of a fetus simply by inspection of its roentgenographic image. With a slender patient, excellent technique and much luck, faint images of the skull, spine and even extremities of a fourteen weeks' fetus may show in roentgenograms. By seventeen weeks the probability of visualization is still not great, but, if the fetus is seen, the image will probably include ribs and the size of the whole will be somewhat greater than that of the average adult kidney. After twenty weeks, ordinary technique should demonstrate the fetus consistently. Shortly after thirty-two weeks, ossification centers will be found at the lower ends of the femurs and just before term they appear in the proximal ends of the tibiae as well.

Estimates of this sort obviously are not sufficiently definite to serve as a check on menstrual history in those cases where there is doubt as to the probable confinement date, and the conceptions of size on which they are based are too coarse for a

comparison with pelvic size in those cases where dystocia is suspected.

Much more satisfactory for the study of disproportion are corrected measurements of skull and extremities, and furthermore, when such net values have been obtained, they constitute the best available means of estimating fetal age. Obviously, a translation of body dimensions into age cannot be absolutely accurate because of the rather large biological variation between age and size of the fetus throughout the last half of gestation, but it should not be necessary to point out to physicians that they are faced with biological variation in almost all the problems in which they are engaged; for example, those concerned with the pulse rate, the blood pressure and the cellular composition of the blood. Distressed by this inescapable variation between fetal size and age, some have questioned the usefulness of attempting the translation at all. I am convinced that the factor of biological variation is no greater here than in any other field of medicine and I am of the opinion that in suitable cases careful roentgen estimates of fetal age may be more dependable than the menstrual history. Furthermore, in spite of the inescapable factor of variation, fetal age calculated from some measurable fetal part sometimes allows a clinically adequate computation of the dimension of some other part that may be vitally concerned in delivery through a barely adequate birth canal and yet be, for some reason, inaccessible to direct measurement.

Theoretically roentgenograms are worked up in four and sometimes five distinct steps: (1) the making of gross measurements; (2) correcting these values for distortion; (3) studying the proportionality between measured fetal parts and birth canal; (4) relating net dimensions to fetal age; (5) sometimes computing from the age the dimensions of certain fetal parts inaccessible to direct mensuration. Practically the steps are so interrelated that the descriptions of each are not easily separated from one another.

AVAILABLE ANATOMIC DATA

There have been published several tables and graphs of fetal age computed from roentgenographic measurements of the fetal skull, but I prefer to employ equations and graphs based on the very extensive anthropometric studies of Scammon and Calkins.[13] There are presented here four such charts and the preparation of others is contemplated.

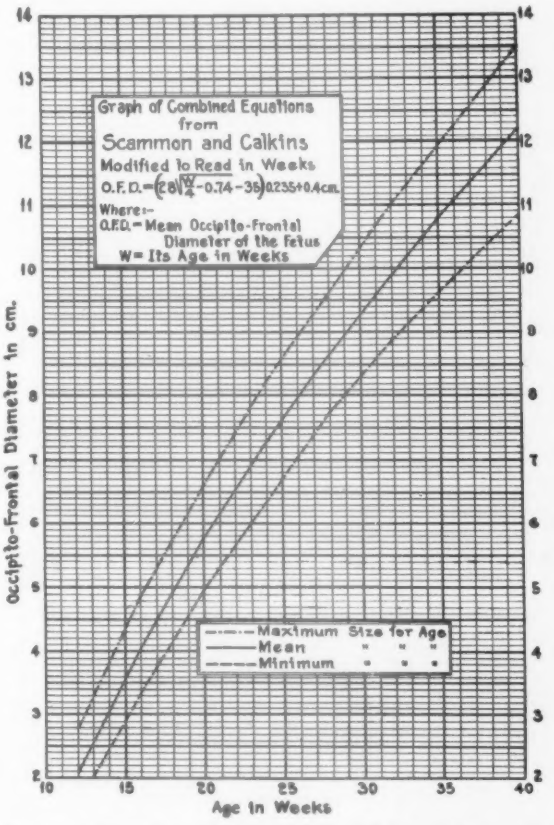


Fig. 18. Graph for computation of fetal age in weeks from net occipitofrontal diameter.

OCCIPITOFRONTAL DIAMETER CHART

Figure 18, for occipitofrontal diameter, first published in 1932[14] but since then redrawn to read in weeks instead of calendar months, was constructed in the following manner:

The Scammon and Calkins equation for crown-heel length in terms of age reads:

$$L = 28\sqrt{T - 0.74} - 35 \qquad (4)$$

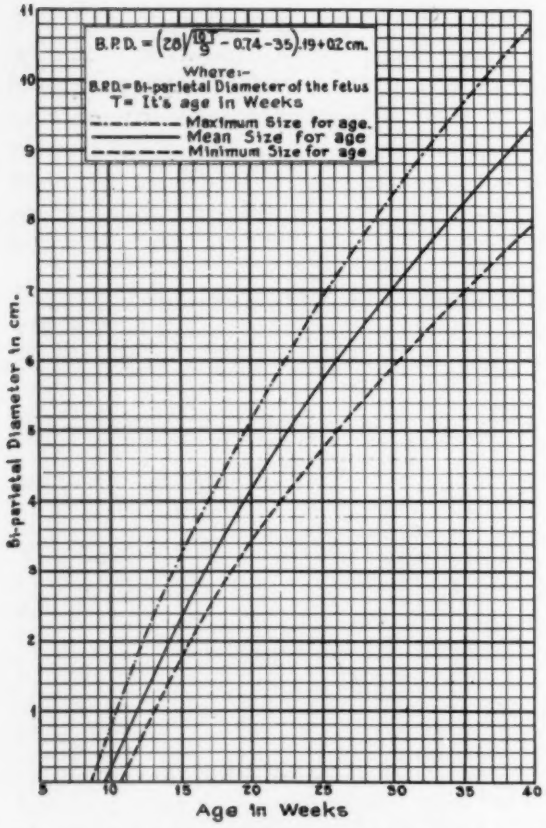

B.P.D. = (28√(T/5 − 0.74) − 35).19+02 cm.
Where:-
B.P.D.=Bi-parietal Diameter of the Fetus
T= It's age in Weeks
Maximum Size for age.
Mean Size for age
Minimum Size for age
Bi-parietal Diameter in cm.
Age in Weeks

FIG. 19. Graph for computation of fetal age in weeks from biparietal diameter.

where L = crown-heel length in cm.; T = age in lunar months.
Substituting $W/4$ for T the equation becomes:

$$L = 28\sqrt{\frac{W}{4} - 0.74} - 35 \qquad (5)$$

where W = age in weeks.
Substituting this value for L in the Scammon and Calkins equation for occipitofrontal diameter in terms of crown-heel length:

$$O.F.D. = 0.235L + 0.4 \text{ cm.} \qquad (6)$$

where $O.F.D.$ = occipitofrontal diameter in cm., the result becomes:

$$O.F.D. = \left(28\sqrt{\frac{W}{4} - 0.74} - 35\right) 0.235 + 0.4 \text{ cm.} \qquad (7)$$

BIPARIETAL DIAMETER CHART

Figure 19, a graph for biparietal diameter, is drawn from:

$$B.P.D. = \left(28\sqrt{\frac{W}{4} - 0.74} - 35\right) 0.19 + 0.2 \text{ cm.} \qquad (8)$$

where $B.P.D.$ = biparietal diameter in cm. This was obtained by substituting equation (5) in the converted Scammon and Calkins equation for biparietal diameter in terms of L.

$$B.P.D. = 0.19\ L + 0.2 \text{ cm.}^* \qquad (9)$$

Figures 20 and 21 require independent consideration.

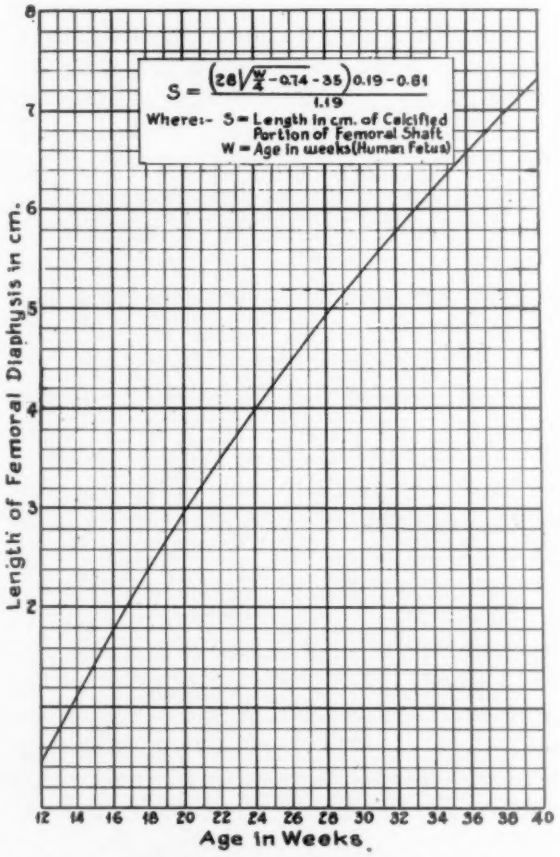

S = ((28√(W/4 − 0.74) − 35) 0.19 − 0.81) / 1.19
Where:- S = Length in cm. of Calcified Portion of Femoral Shaft
W = Age in weeks (Human Fetus)
Length of Femoral Diaphysis in cm.
Age in Weeks

FIG. 20. Graph for computation of fetal age in weeks from net length of calcified portion of shaft of femur.

* The value happens to be identical with that for thigh length, equation (11).

FETAL AGE IN TERMS OF LENGTH OF FEMORAL SHAFT

Some years ago, Dr. Ruth Stocking, working in this laboratory, made caliper measurements of thigh length and parallax roentgenographic measurements of femoral shaft length on approximately 100 human fetuses ranging in age from sixteen to thirty-eight weeks. These measurements treated by standard mathematical procedures yielded:

$$S = \frac{T - 0.61}{1.19} \qquad (10)$$

where S = the length in cm. of the calcified portion of the shaft of the femur as computed from the roentgenographic shadow after correcting for distortion; T = the length in cm. of the thigh as measured by calipers resting on the skin just above the most prominent point of the great trochanter and the most prominent point of the lateral condyle of the femur.

The Scammon and Calkins equation for thigh length in terms of crown-heel length reads:

$$T = 0.19\,L - 0.2 \text{ cm.} \qquad (11)$$

Substituting equation (5) for L we have:

$$T = 0.19\left(28\sqrt{\frac{W}{4} - 0.74} - 35\right) - 0.2 \text{ cm.} \qquad (12)$$

and substituting this value of T in equation (10) we have:

$$S = \frac{\left(28\sqrt{\frac{W}{4} - 0.74} - 35\right)0.19 - 0.2 \text{ cm.}}{1.19} \qquad (13)$$

from which the graph shown in Figure 20 was made.

FETAL AGE IN TERMS OF AVERAGE NET CIRCUMFERENCE FROM RIGHT-ANGLE VIEWS

When the position of the fetus brings the occipitofrontal diameter or the biparietal diameter approximately parallel with the film in one or more of the views, and when by parallax or other methods one or both of these dimensions can be corrected for distortion, it is a simple matter to lay off such net values on the corresponding graphs and thus read off the probable age in weeks. When this cannot be done it is sometimes possible to make stereoroentgenometer measurements of femoral shaft length and then employ the graph for that dimension. When this too is impossible a maneuver suggested by the work of Ball and Marchbanks[1] (discussed elsewhere in this paper) can sometimes be employed.

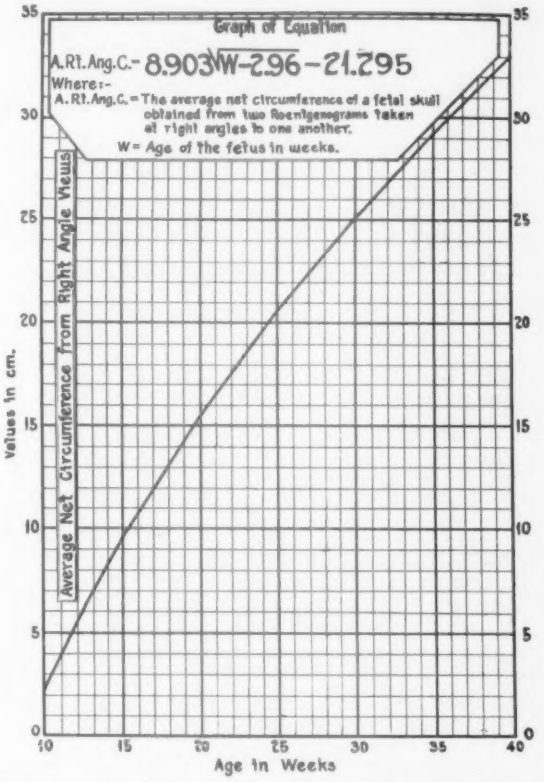


FIG. 21. Graph for computation of fetal age in weeks from average corrected circumference of skull by 90° triangulation methods.

Ball and Marchbanks point out that in an oblate spheroid the mean of any two circumferences taken at right angles to one another is identical with the mean of any pair of circumferences provided they are taken at right angles to one another. They

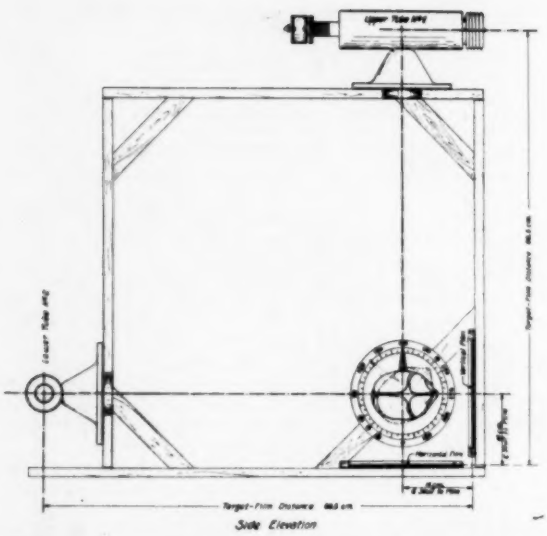


FIG. 22. Apparatus for testing validity of assumption that fetal skull may be treated as though it were an oblate spheroid.

believe that the fetal skull is for all practical purposes an oblate spheroid and conclude that, regardless of the obliquity of the view, a determination of the net mean circumference of the skull from a pair of roentgenograms should bear a significant relationship to its volume and thus to its various diameters.

As a result of experiments on a dried fetal skull, I am of the opinion that Ball and Marchbanks' general proposition is probably correct and by means of certain assumptions and the manipulation of formulae from Scammon and Calkins I have been able to relate this rather artificial yet apparently useful skull measurement to age.

EXPERIMENTS WITH DRIED FETAL SKULL

The dried skull of a human fetus was mounted on a wooden spindle so that it could be rotated through 360° about an axis passing from the vertex through the foramen magnum (Fig. 22), angular relationship between occipitofrontal diameter and a perpendicular to the base of the apparatus being indicated by a pointer. Horizontal and vertical film holders were arranged with their centers each exactly 10 cm. distant from the center of the skull at the axis of rotation, and upper and lower roentgen tubes were mounted with their targets exactly 88.5 cm. distant from the centers of the horizontal and vertical films respectively.

Ten pairs of films were made with the skull in ten different positions relative to the base of the apparatus. For each pair the circumferences of the skull shadow were measured, added and averaged, and this average value was in each case multiplied by 0.83 to obtain the net average circumference (because D was 88.5 and $O.D.$ 15—see equation (1)). When this had been done it was found that for the ten pairs made at a variety of angles the lowest value was 27.4 cm., the highest 27.8, truly an insignificant difference. For this particular skull, therefore, Ball's contention is found to be correct and there is little reason to doubt that the relationship is a general one.

EQUATION AND GRAPH

Unless anatomists are willing to dissect fetal calvaria free from the face bones and neck, obviously they cannot measure occipitofrontal or biparietal circumference as it was measured in these films. They do, however, regularly measure occipitofrontal circumference in a plane parallel with the base of the skull, and they do measure biparietal diameter. Preliminary tests on this particular dried skull suggested that occipitofrontal circumference measured in the plane of the base was practically identical with that measured along the base and over the vertex. Furthermore, though a cross-section through the biparietal region appeared heart-shaped rather than round, the circumference at this point proved to be practically identical with the circumference of a circle having the biparietal width as its diameter. It seemed possible, therefore, to convert Scammon and Calkins' equation for occiptofrontal circumference and biparietal diameter into an equation and a graph for the determination of age from average net circumfer-

ence obtained from a pair of right-angle roentgenograms (Fig. 21).

Scammon and Calkins have published

$$O.F.C. = 0.675L + 1.3 \text{ cm.} \quad (14)$$

where $O.F.C.$ = occipitofrontal circumference in cm.

Multiplying the equation for biparietal diameter (equation (9)) by π we obtain an expression for biparietal circumference:

$$B.P.C. = \pi(0.19L + 0.2) \quad (15)$$

where $B.P.C.$ = biparietal circumference in cm.

Adding equations (14) and (15) and extracting the mean, there results

$$\frac{O.F.C. + B.P.C.}{2} = \frac{(0.675L + 1.3 \text{ cm.}) + (0.19L + 0.2)\pi}{2} \quad (16)$$

Substituting now the value for L in terms of weeks (equation (5)) the equation becomes:

$$A.C.C. = \frac{\left[\left(28\sqrt{\frac{W}{4} - 0.74} - 35\right)0.675 + 1.3 \text{ cm.}\right] + \left[\left(28\sqrt{\frac{W}{4} - 0.74} - 35\right)0.19 + 2 \text{ cm.}\right]\pi}{2} \quad (17)$$

where $A.C.C.$ = the average corrected circumference of an unborn fetal skull as taken from two roentgenograms made at right angles to one another.

This equation can be simplified to read:

$$A.C.C. = 8.903\sqrt{W - 2.96} - 21.295 \quad (17a)$$

and can be expressed as a graph (Fig. 21).

EXAMPLES OF TECHNIQUE OF FETOMETRY FROM STEREOROENTGENOGRAMS

In a theoretical case in which a full term fetus is in vertex presentation and multiple stereoroentgenograms have been made, the skull shows well in both films made in Position I (Fig. 7) and appears to lie with its sagittal suture parallel with the plane of the film. The occipitofrontal diameter is measured in both films and the mean of both readings is extracted and recorded as the gross occipitofrontal diameter. Using a wax pencil, lines are now drawn on both films perpendicular to the long axis of the film and tangent to the lower border of the skull. The films are now superimposed with their register holes coinciding, after which the parallax (P) or distance between the two pencil marks is measured and recorded. From the appropriate graph (Fig. 16), parallax is converted to a correction factor and this factor multiplied by the gross occipitofrontal diameter yields net or actual occipitofrontal diameter.

Net occipitofrontal diameter laid off on the graph in Figure 18 shows the probable age of the fetus.

If it is the coronal plane that happens to lie parallel with the plane of the film in some one of the views, biparietal diameter is corrected and applied in the same manner; but if the length of the femoral shaft must be used, its net value should be obtained by means of a measuring stereoscope or a stereoroentgenometer rather than from the graph of equation (1).

If none of these dimensions can be measured, equation (17) is applied as follows: Using an ordinary map measure the circumference of the skull is measured in both frontal films (Position I, Fig. 7) and both lateral films (Position III, Fig. 9) and the mean gross circumferences for both views are recorded. Measuring the parallax in both views these gross values are reduced to net circumferences. The sum of these two net circumferences added and divided by two yields a value that can be taken to the graph (Fig. 21) for a direct reading of fetal age.

NON-STEREOSCOPIC TWO-FILM METHODS

Ball and Marchbanks employ two non-stereoscopic films, one made in the frontal position, the other in the lateral position. This makes it difficult, if not impossible, for them to classify pelves along the lines suggested by Caldwell and Moloy, but it does make for economy and simplicity. From the average net circumference of the skull as seen in the two right-angle views, an equivalent skull volume in cubic centimeters is computed. Having measured the net true conjugate of the pelvis and the net bispinous diameter, the shorter of these dimensions is used as a diameter in computing the volume of a second sphere. The ratio of equivalent pelvic volume divided by equivalent skull volume is considered indicative of the "passenger-passage" ratio. Tables showing the normal range of this ratio have not yet been published but it seems obvious that values well in excess of 1 should be found in normal cases.

The method has much to commend it but at least two objections may be made on theoretical grounds: (1) The means by which triangular distortion is corrected, while perhaps sufficiently accurate for clinical purposes, is not mathematically sound. (2) Since the films are made in the recumbent position there is reason to fear that as the patient turns onto her side for the lateral film the fetal head may move toward the dependent side, thus still further reducing the accuracy of the computations.

BALL'S METHOD OF CORRECTING FOR TRIANGULAR DISTORTION

Observing the skull in the frontal film, one notes that in a particular case its center lies 10 cm. from the lateral border of the right great trochanter. Assuming that this value is approximately the same as the actual distance between center of head and the right side of the body (a purely empirical assumption, the validity of which is by no means established), one adds to this the distance from the table top to the film (let us say 5 cm.) and obtains 15 cm. as the object-film distance at the time the lateral film was made.

In the film made in the right lateral position it is found that the distance between the center of the fetal head and the posterior surface of the sacrum is 6 cm., and by reasoning similar to that described above the object-film distance for the frontal film is recorded as 11 cm.

THE PELVICEPHALOMETER

If for the measurement of the gross skull circumferences one has used not an ordinary map measure but instead Ball and Marchbanks' cephalometer, the dial of that instrument can now be used to correct for triangular distortion and translate the corrected values of circumference and diameter into equivalent volumes.

The tracing wheel of the instrument drives a pointer about a large disk on which are incorporated a polar graph of the relations expressed in equation (1) for a particular target-film distance and the values of spheres having circumferences of from 5 to 45 cm. or diameters of from 5 to 15 cm. Thirteen concentric circles drawn with the center of the dial as their center are numbered from 30 to 5 cm. reading outward from the center. These represent object-film distances varying from 30 to 5 cm. The same figures spaced in the same fashion appear on the body of the pointer.

First setting the pointer at 0, one carries the tracing wheel about the margin of the skull shadow in the lateral film and reads off at the tip of the pointer the circumference of the shadow (for example, it might be 25 cm.). Since the object-film distance for this view has already been computed as 15 cm., the pointer is moved clockwise until the crossing of its center line and its 15 cm. line coincides with the polar curve that originates at the 25 cm. mark on the periphery of the dial. If the target-film distance employed is 36 inches and a suitably designed dial has been employed, it will now be found that the tip

of the pointer is resting just short of 21, which is the net circumference for these particular values of object-film distance and target-film distance. Furthermore, by reading inward from 21, one finds that a sphere having a circumference of 21 cm. has a volume of 156 cubic centimeters.

FURTHER APPLICATION OF 90° TRIANGULATION

Because of their simplicity and inexpensiveness, two-film methods of this general type will probably be employed to an increasing extent and, since they do not conform well to either of the two general groups now recognized (position methods and parallax methods), it seems desirable to find a general term to describe them. The term "90° triangulation" is suggested as a possible choice.

Impressed with the possibilities inherent in 90° triangulation, I have developed a technique of this sort in which the possibility of movement of the fetal head during the making of the two films is reduced and the correction for triangular distortion is accomplished by straightforward mathematical means.

AN OBSTETRICIAL JACKET

A trough-like jacket or corset (Fig. 17), made of welded aluminum tubing covered by stretched stockinet impregnated with celluloid, is designed so that its sides are parallel with one another and perpendicular to the back. This jacket is slipped over the back of the standing patient and held in place by her as she is tilted backward into the recumbent position on a tilting roentgen table. With the patient recumbent, the jacket is slipped up or down until its center coincides with a point 12 cm. above the pubic symphysis, following which small pillows are stuffed in between the frame and both sides of the body and a compression band is cinched tightly into place (Fig. 14).

The patient is now tilted forward into

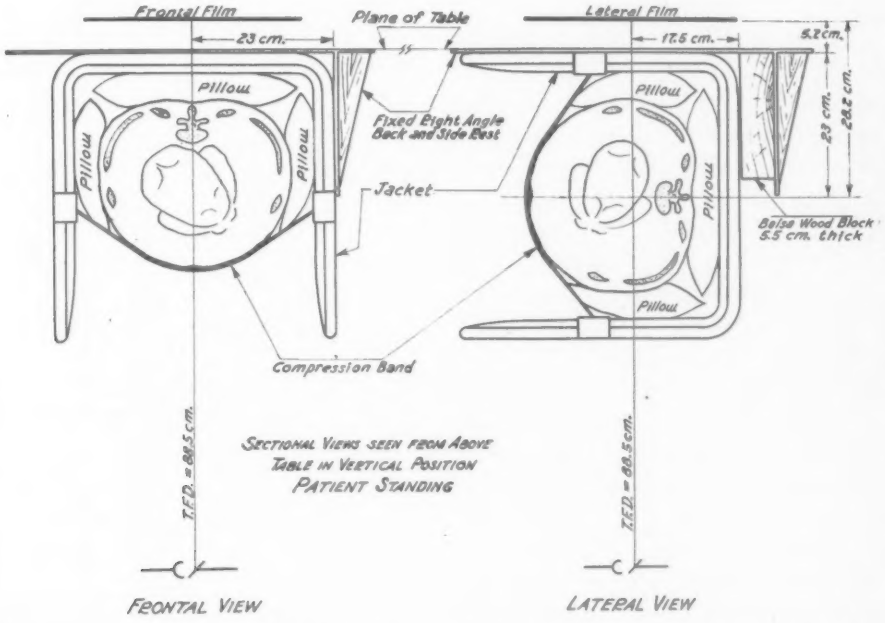


Fig. 23. Pelvimetry and fetometry by the 90° triangulation method. The patient, strapped into a radiotranslucent jacket (see Fig. 17), stands facing the roentgen tube for a frontal film and turns with her left side toward the tube for the lateral film. The relations of target, film axes, and sides and back of frame for both views are known and so it is possible later to compute object-film distance for both films.

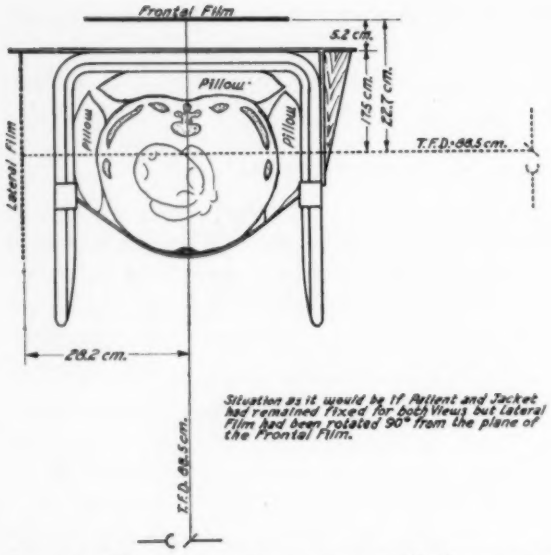


FIG. 24. Figure 23 redrawn as a preliminary step to the understanding of Figures 25 and 26.

the standing position, the back of the jacket being pressed firmly against the table top, its perpendicular left side against a right-angle side rest. With the film lined up until its center lies directly behind the center of the jacket and the tube adjusted until its target is perpendicular to the center of the film and at a known distance from it, the frontal film is made.

The patient now turns 90° toward the right, steps forward for the insertion of a balsa wood block between the back of the jacket and the surface of the right-angle rest; and then with the right side of the jacket pressed firmly against the table top, the back against the balsa wood block and the bottom at the same distance from the floor as in the first exposures, the lateral film is made. Figure 23 shows the relations between tube, patient, jacket and film as they actually are during the making of the films, and Figure 24 as they would have been if the patient had remained stationary but the table top had been moved backward 5.5 cm. and then rotated 90° until it lay in contact with the right side of the jacket. As far as the relations of roentgen shadows to object and tube are concerned, the geometry is the same in both cases, and so in working up the films it is permissible to assume that they are made as in Figure 24. Having located their optical axes and punched out their register holes by means already described, one pencils on the films the centers and circumferences of the skull shadows. Employing a map measure, gross skull circumferences in centimeters are recorded

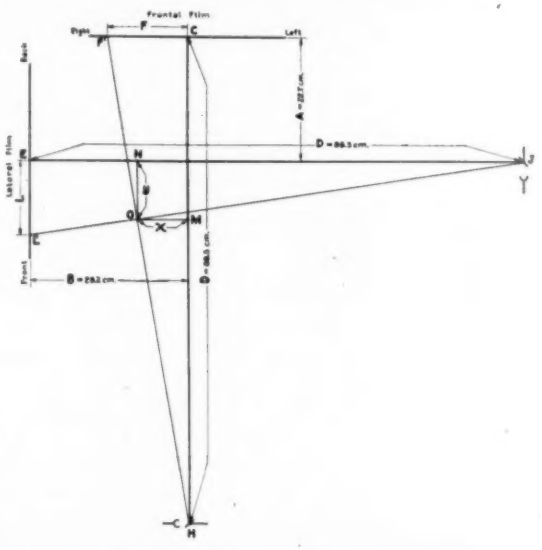


FIG. 25. Diagram of the conditions obtaining in Figure 24. O = the center of the skull of an unborn fetus; C = the optical axis of the frontal film; H = the target of the roentgen-ray tube at the time the frontal film was made; F' = the center of the shadow of the skull in the frontal film; F = the displacement of that center to the right of the optical axis; $\mathcal{J}$ = the target of the roentgen-ray tube at the time the lateral film was made; L' = the displacement of that center in front of the optical axis, E. The distance between the axis of the lateral film and the plane of the frontal film (A) is 22.7 cm. and the distance between the axis of the frontal film and the plane of the lateral film (B) is 28.2 cm. Target-film distance (D) is 88.5 cm. for both films. M is the foot point of a perpendicular X dropped from O to the line HC. N is the foot of a similar perpendicular Y dropped from O to the line $\mathcal{J}E$. Since triangle HMO is similar to triangle HCF' and triangle $\mathcal{J}NO$ is similar to triangle $\mathcal{J}EL'$ it follows that $Y:L::D-(28.2\text{ cm.}-X):D$, and that $X:F::D-(22.7\text{ cm.}+Y):D$. Obviously these equations can be solved for numerical values of X and Y and thus the perpendicular distances between O and the lateral film and O and the frontal film can be found. Better than equations, however, is the plotting diagram (Fig. 26) from which $O.F.D.$ can be obtained without computations of any sort.

and by means of a centimeter rule the displacement between optical axes and centers of skull shadows is measured. (These displacements are recorded as being to the right or left side of the patient's body in the frontal film, back or front in the lateral frontal axis and plane of lateral film (*B*) are known (22.7 cm. and 28.2 cm. respectively). The target-film distance (*D*) is known (88.5 cm.). Obviously the values of *X* and *Y* can be computed and thus the distance between the center of the skull

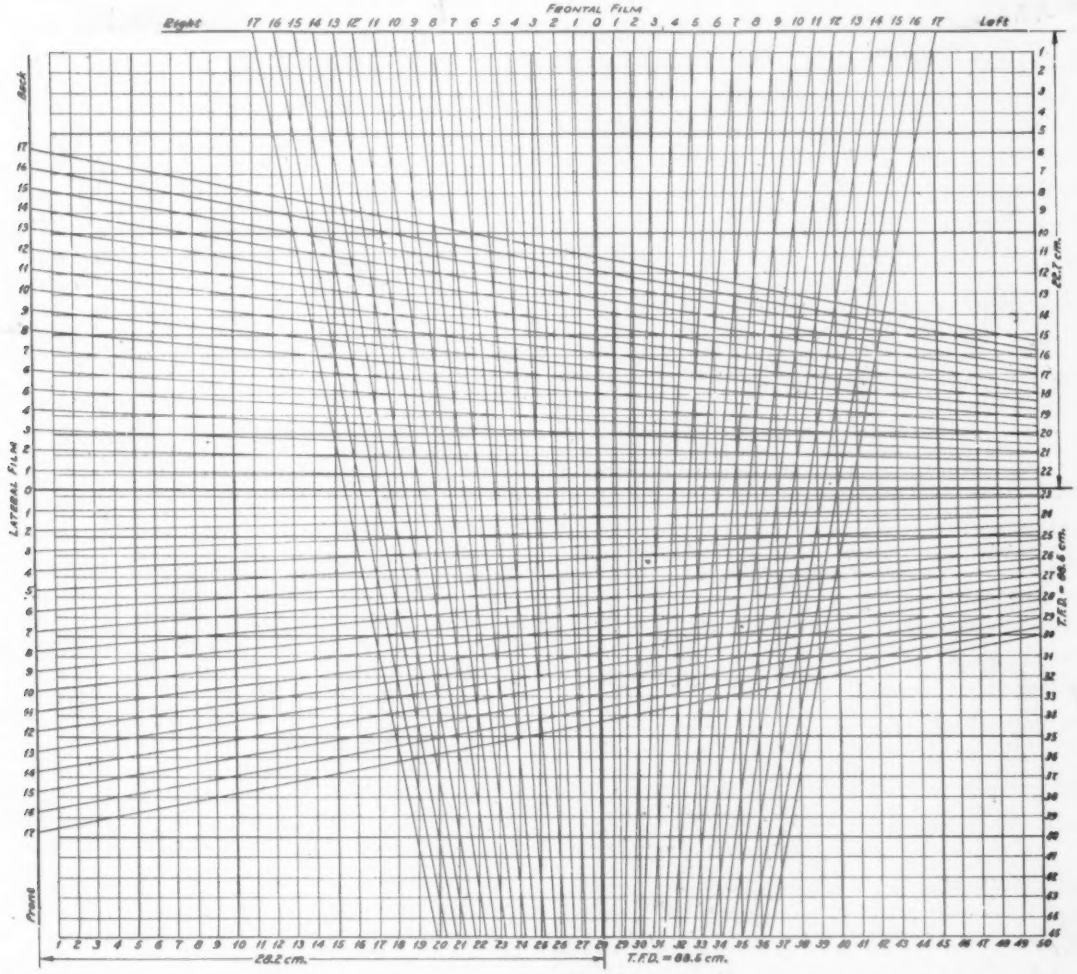


Fig. 26. Chart for determining object-film distance in 90° triangulation methods by plotting measured displacement between center of shadow and optical axis in both films.

film.) In Figure 25 the point *O* represents the actual location of the center of a fetal skull relative to the target of the roentgen ray tube and the two films. *F'* represents its shadow in the frontal film and *F* the displacement of this shadow to the right of the axis. *L'* represents the center of the skull shadow in the lateral film and *L* its displacement frontward from the lateral axis. The distance between lateral axis and plane of frontal film (*A*) and between and each of the films can be found. The equations for finding these distances, though simple in theory, are much too involved for practical use but they can be reduced to a simple graph (Fig. 26).

OBJECT-FILM DISTANCE FROM 90° TRIANGULATION GRAPH

On a printed form (Fig. 26) one records the location of the centers of the two shadows of the skull relative to the axes

of frontal and lateral films. Having done this, one follows the diagonal lines leading from the points thus recorded and reads off at their crossing the net object-film distance for each view. These values carried to graph of equation (1) (Fig. 15) supply correction factors which applied to the gross circumferences already recorded yield net circumferences. By similar means such skull and pelvic diameters as can be visualized are corrected for distortion and thus rendered suitable for estimates of fetal age and the obstetrical adequacy of the pelvis.

SUMMARY

1. Multiple stereoroentgenograms are the media of choice for a complete roentgenologic survey of pelvis and fetus.

2. For most phases of the mathematical work-up of such films it is a matter of personal choice whether the stereoroentgenometer or a measuring stereoscope shall be used, but for certain phases graphs appear to be preferable to either of these instruments.

3. Classifications and tables by Caldwell and Moloy are of definite usefulness in interpreting qualitative and quantitative findings in the pelvis.

4. There are presented four equations and graphs for determination of fetal age from skull and extremity dimensions, one of these being based on ideas first introduced by Ball and Marchbanks.

5. The term "90° triangulation" is suggested as a third division of the general types of roentgen pelvimetry and cephalometry, the other two types at present recognized being position methods and parallax methods.

6. A new 90° triangulation method is described.

REFERENCES

1. Ball, R. P., and Marchbanks, S. S. Roentgen pelvimetry and fetal cephalometry; a new technic. *Radiology*, 1935, *24*, 77–84.

2. Caldwell, W. E., and Moloy, H. C. Anatomical variations in the female pelvis and their effect in labor, with a suggested classification. *Am. J. Obst. & Gynec.*, 1933, *26*, 479–505.

3. Chamberlain, W. E., and Newell, R. R. Pelvimetry by means of the roentgen ray. Am. J. Roentgenol. & Rad. Therapy, 1921, *8*, 272–276.

4. Clifford, S. H. The stereoroentgenometric method of fetometry and pelvimetry with its obstetrical application. *West Virginia M. J.*, 1935, *31*, 401–414.

5. Davidson, J. M. A method of localization by means of roentgen rays. *Arch. Roentg. Ray*, 1898, *2*, 64–67.

6. Deville, E. *Tr. Royal Soc. Canada*, 1902–1903.

7. Hasselwander, A. Beiträge zur Methodik der Röntgenographie. II. Die Stereoröntgenogrammetrie. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1916–1917, *24*, 345–368.

8. Hodges, P. C. An epiphyseal chart. Am. J. Roentgenol. & Rad. Therapy, 1933, *30*, 809–810.

9. Hodges, P. C., and Ledoux, A. C. Roentgen-ray pelvimetry—a simplified stereoroentgenographic method. Am. J. Roentgenol. & Rad. Therapy, 1932, *27*, 83–96.

10. Johnson, C. R. Stereoroentgenometry; method for mensuration by means of roentgen ray. *Am. J. Surg.*, 1930, *8*, 151–163.

11. Manges, W. F. Roentgenographic pelvimetry. *Am. J. Obst.*, 1912, *65*, 622.

12. Pulfrich, C. Raumbildmeszgeräte für Stereoskopische Röntgenaufnahmen. *Ztschr. f. Instrumentenk.*, 1918, *38*, 17.

13. Scammon, R. E., and Calkins, L. A. The Development and Growth of the External Dimensions of the Human Body in the Fetal Period. The University of Minnesota Press, 1929.

14. Schnitker, M. A., Hodges, P. C., and Whitacre, F. E. Roentgenologic evidence of fetal death. Am. J. Roentgenol. & Rad. Therapy, 1932, *28*, 349–371.

15. Thoms, H. The Obstetric Pelvis. Williams and Wilkins Company, Baltimore, 1935.

16. Trendelenburg, W. Ein neues Verfahren zur Raummessung an Stereoskopischen Aufnahmen Insbesondere an Röntgenaufnahmen. *Wien. klin. Wchnschr.*, 1915, *28*, 169.

17. Walton, H. J. Intrauterine roentgen cephalometry and pelvimetry. Am. J. Roentgenol. & Rad. Therapy, 1931, *25*, 758–760.

BENIGN GIANT CELL TUMOR OF A RIB*

REPORT OF A CASE

By LAWRENCE M. HILT, M.D.
Butterworth Hospital
GRAND RAPIDS, MICHIGAN

IT IS assumed by most clinicians and roentgenologists that a giant cell bone tumor presents a rather typical roentgenographic appearance, and that diagnosis of these lesions offers no particular difficulty. This fact is supported by many of the texts recently published which deal with this subject, and in some current writings. Kirklin and Moore, in 1932, called attention to an atypical appearance conclusively demonstrated to be giant cell tumor of bone. Osteolysis was present in 50 per cent of the giant cell tumors they collected. Kirklin, in discussing their paper, makes no claim of originality, but calls attention to previous reports. They infer that this appearance is probably one of the late manifestations of the process, but are careful not to draw any dogmatic conclusions and have thoughtfully left the question open for further discussion.

It seems worth while to present a case which exhibited osteolytic manifestations early and in the course of the disease developed a trabeculated appearance. This case has been followed over a period of two years. According to Samson and Haight only 10 cases of giant cell bone tumor of a rib have been reported.

CASE REPORT

A white female, aged fifteen. Thinks she bruised posterior left shoulder about two months previous to the time she began to notice pain and swelling in this region. Does not remember direct trauma to this area. The area began to enlarge and became more painful. In two weeks there was a tumor mass about 6 cm. in diameter and 2 cm. in height, which was tender to pressure.

On November 26, 1934, a roentgenogram (Fig. 1) showed a destructive process of the 5th rib on the left near its proximal end. The line of destruction extends for a length of about 3.5 cm. On the distal surface of the lesion, the periosteum appears to be stripped away from the bone and extends out into the soft tissues. There is no evidence of a bony mass in the soft tissues, nor of bony regeneration in the lesion. There is a circular area at the proximal end of the 1st rib which measures 1 cm. in diameter and has the appearance of a healed bone cyst. This film was taken with the patient's back to the plate.

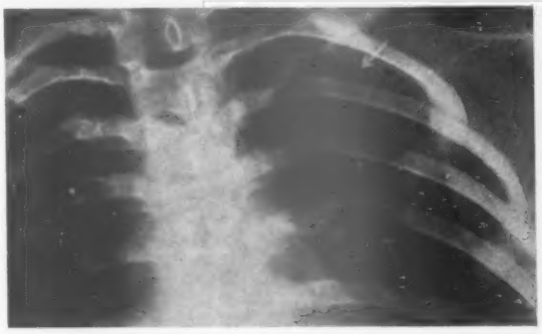


FIG. 1

The patient was admitted to the hospital and on January 8, 1935, a biopsy was taken. The findings, as interpreted by Dr. F. W. Light, in reviewing the sections recently, are as follows:

Long spindle cells, possessing rather plump oval nuclei, predominate. They are disposed in an apparently random fashion, interlacing in an irregular way, so as to form a compact structure, without collecting themselves into distinct bundles. In many places, small bony spicules are present, surrounded by the tissue just mentioned. Each spicule is bordered by a complete layer of osteoblasts. At a few points, there appears to be some independent growth of osteoblasts, unassociated with bone. There are present some scattered giant cells, whose number, while variable, never becomes very large. They lie free in the spindle cell stroma, in most instances, and are not applied to the surfaces of the bone spicules. These giant cells are not excessively large, and have, as a rule, eight or ten nuclei. The osteoblasts, especially when growing in solid clumps, exhibit some pleomorphism, and show scattered mitotic figures. The spindle cells, while fairly uniform in size, also show a good deal of mitosis in some regions. The

* From St. John's Hospital, Springfield, Illinois.

whole specimen is rather vascular, and there are several small interstitial hemorrhages.

On February 4, 1935, an anteroposterior roentgenogram (Fig. 2) of the chest was taken,

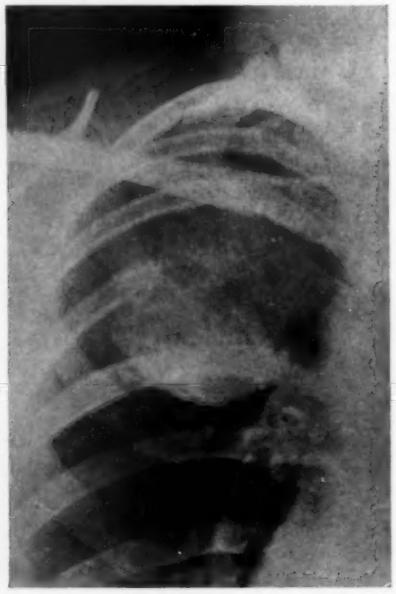


FIG. 2

FIG. 3

which shows a rather indefinite, opaque area on the left. There is no bony trabeculation. The lesion presents a rather uniform, somewhat circular opacity. In the position in which the patient was examined, it is impossible, definitely, to outline the previously described area in the 1st rib.

A film was taken August 26, 1935 (Fig. 3), with the patient in the supine position. It shows the previously described lesion to have a trabeculated appearance, to be definitely encapsulated, and to have the so-called typical giant cell tumor appearance. The mass is somewhat circular in outline and measures about 5.5 cm. in one direction and 4 cm. in the other. Due to position, the cystic area in the 1st rib can be only indefinitely outlined and does not appear to have changed in appearance since the original examination, practically a year ago.

FIG. 4

On November 20, 1936, this patient was again examined (Fig. 4). The tumor mass is smaller by about 1 cm. in each direction and shows more trabeculation, more calcification, more filling in of the tumor area, and has a healed appearance, which was described nearly two years previously. A careful roentgenoscopic examination failed to reveal any evidence of pathology in the long bones or chest.

On January 22, 1935, roentgen therapy was started. Between this time and October 8, 1935, 2,700 r, measured in air, with 200 kv. (peak), filtered through 0.5 mm. Cu and 1 mm. Al, was given to a field 10×10. cm. in size. This was divided into several series. There has been no skin reaction or telangiectasis. The skin was examined November 20, 1936, and has a normal appearance and texture. Examination of the area shows no tumor formation. There is no

tenderness, although a hard mass can be felt by deep palpation. The two sides of the chest appear symmetrical. The patient has gained 60 pounds in weight since January, 1935, and to all appearances is a healthy seventeen year old girl.

Writers on therapy are roughly divided into two classes: those who advocate irradiation, and those who prefer surgery or some form of surgery, plus irradiation for recurrences. Equally good results are claimed by the proponents of each type of treatment. Before one attempts an evaluation of any type of therapy, it is well to realize that giant cell bone tumor is not a common lesion and that few observers are able to report a sufficient number of cases with a thorough follow-up to permit reliable conclusions to be reached. It would seem that Pfahler, Herendeen, Peirce, Ewing, and a few others, have such necessary experience. Their recommendation that irradiation, preferably by means of the roentgen ray, is a method of choice, is not to be dismissed lightly. It is admitted that, if treatment by this means is employed, microscopic confirmation of the diagnosis is not secured. At some time during the course of the disease, the films should furnish ample evidence of the nature of the lesion. The appearance following therapy is a valuable aid in diagnosis; even in the absence of microscopic sections. Borak's statement that there will be no harm to bone growth unless the skin is damaged is logical.

Ewing says, "At the present time the prognosis for a patient with giant cell tumor in this country is comparatively unfavorable, owing to the unfortunate results of surgical interference." He further states that not all cases of giant cell tumor are amenable to irradiation.

A rational conclusion is that surgery should be reserved for failures by irradiation, and not irradiation for surgical failures. There certainly exists more danger that an osteomyelitis will develop after surgical intervention than that the lesion will become malignant, provided adequate radiation is used.

There are many who believe that giant cell tumor of bone must be associated with osteitis fibrosa generalisata. The accompanying bone cyst of the first rib may or may not have some significance.

SUMMARY

1. A case is reported of a giant cell tumor of a rib which presented osteolytic manifestations early, and later had a typical trabeculated appearance.

2. The microscopic findings are not characteristic of a giant cell tumor and suggest the possibility of an osteolytic sarcoma.

3. Radiation therapy seems to have been effective and of aid in the establishment of the diagnosis.

Grateful appreciation is hereby expressed to Drs. Robert Smith and P. W. Kokennes for the clinical data on this case.

REFERENCES

1. Brailsford, J. F. Radiology of Bones and Joints. William Wood & Co., Baltimore, 1934.
2. Evans, W. A., and Leucutia, T. Value of roentgen-ray therapy in primary malignant tumors and benign giant cell tumor of bone. Am. J. Roentgenol. & Rad. Therapy, 1928, *20*, 303–338.
3. Ewing, J. Discussion. Am. J. Roentgenol. & Rad. Therapy, 1932, *28*, 189.
4. Golden, Ross, Editor. Diagnostic Roentgenology. Thomas Nelson & Sons, New York, 1935.
5. Herendeen, R. E. Roentgen ray in the treatment of giant-cell tumors. Am. J. Roentgenol. & Rad. Therapy, 1924, *12*, 117–125.
6. Kirklin, B. R., and Moore, C. Roentgenologic manifestations of giant-cell tumor. Am. J. Roentgenol. & Rad. Therapy, 1932, *28*, 145–150.
7. Peirce, C. B. Giant-cell bone tumor. Am. J. Roentgenol. & Rad. Therapy, 1932, *28*, 167–188.
8. Pfahler, G. E., and Parry, L. D. Treatment of giant-cell bone tumors by roentgen irradiation. Am. J. Roentgenol. & Rad. Therapy, 1932, *28*, 151–166.
9. Platt, H. Some remarks on giant cell tumor of bone. *Surg., Gynec. & Obst.*, 1935, *60*, 318–329.
10. Samson, P. C., and Haight, C. Giant-cell bone tumor of costal origin. *J. Am. M. Ass.*, 1935, *105*, 1020–1023.

HERNIATION OF THE STOMACH INTO THE SCROTUM

REPORT OF CASE

By FRANZ J. LUST, M.D.
NEW YORK CITY

THERE have been many reports on the oral displacement of the stomach. Nearly every roentgenologist has had the opportunity to see cases of this kind. This case report deals, however, with a caudal displacement, a condition which is much rarer.

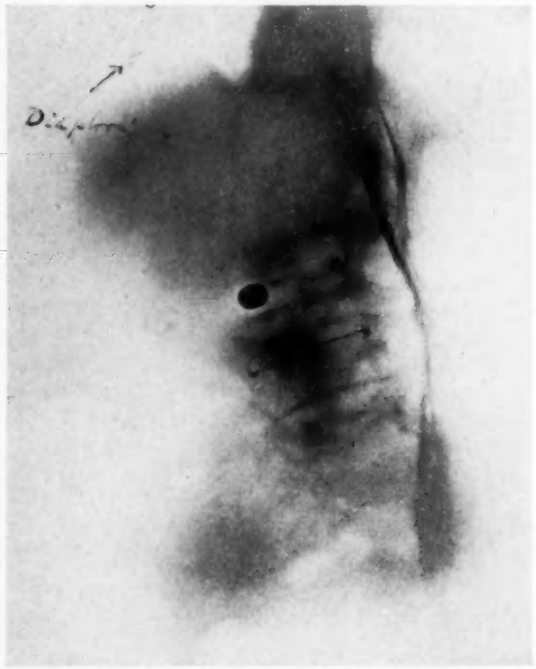


FIG. 1. Esophagus elongated. Cardia near the fourth lumbar vertebra.

A man, aged sixty-two, came for a routine examination. A left inguinal hernia was found, which he had had for more than thirty years. This hernia caused him no discomfort. The roentgen examination in the upright position showed a markedly elongated esophagus (Fig. 1) which extended down to the level of the iliac crests, where the cardia was found. The stomach was also elongated, two-thirds of it being seen in the left inguinal hernia (Fig. 2). The lower pole of the stomach was at the level of the middle of the femur. It was hookshaped and showed no intrinsic lesions. The patient was asked to reduce his hernia which he did without difficulty while lying on his back. The next roentgenogram (Fig. 3) showed the reduction of the herniated esophagus and stomach. The esophagus appeared to be of nearly normal length, did not show convolutions and was found to lie completely in the thoracic cavity. The stomach returned completely to the abdominal cavity and showed a normal contour. At the twenty-four hour examination there was no barium residue in the stomach but barium-filled loops of the colon were seen in the hernial sac (Fig. 4).

This case is interesting for several reasons. I have been unable to find a single case of this type diagnosed roentgenologically. There is apparently only one similar case, an illustration of which is found in Henke-Lubarsch,[1] showing the

FIG. 2. Roentgenogram showing stomach in scrotum.

stomach as contents of an inguinal hernia and found at autopsy. There are some reports of occasional findings of small parts of the stomach in a hernia, but there were never illustrations of these cases.[1]

More important still is the demonstration of the astonishing elasticity of the abdominal organs. Changes in the length of the esophagus are reported in several instances. An elongated esophagus, however, is very rarely found. Rosselet and Mengis[5] describe a case in which the cardia was at the rear part of the stomach and 20 cm. under the diaphragm. Kahlstorf[3] reports a case of carcinosarcoma of the stomach with elongation of the esophagus. Kirklin[4] discusses cases in which a slight prolongation of the esophagus facilitated a total gastrectomy. Heyers[2] saw an esophagus which was long and had a corkscrew appearance.

In spite of the unusual abnormality our patient had no discomfort. He probably had had this condition for many years. In spite of the long duration, the elasticity of the esophagus was not impaired. This case illustrates very well that considerable displacements of internal organs may not produce any symptoms and that the function of these organs is not impaired. Therefore one should be very careful about recommending surgical procedures in similar cases.

Fig. 3. After reduction of the hernia. The stomach is in the abdominal cavity.

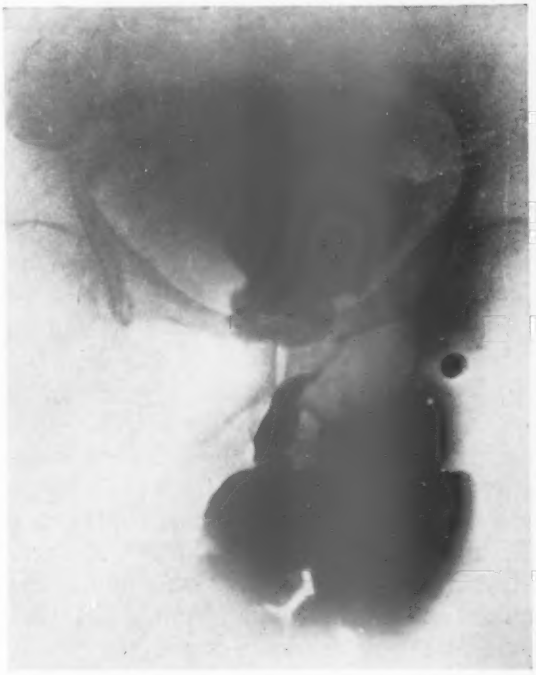


Fig. 4. Twenty-four hour roentgenogram showing colon in the scrotum.

REFERENCES

1. Henke-Lubarsch. Handbuch der speziellen pathologischen Anatomie und Histologie. Julius Springer, Berlin, Vol. IV, Part III, p. 129.

2. Heyers, B. Korkenzieherform der Speiseröhre. *Deutsche med. Wchnschr.*, 1931, *57*, 1897–1898.

3. Kahlstorf, A. Beitrag zur Röntgendiagnose seltener bösartiger Gewachse der Speiseröhre. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1930, *42*, 421–435.

4. Kirklin, B. R. Roentgenologic demonstration of anomalous prolongation of esophagus below diaphragm, facilitating total gastrectomy. *Am. J. Surg.*, 1932, *16*, 12–13.

5. Rosselet, A., and Mengis, O. Sur une anomalie congénitale de l'estomac. *Acta radiol.*, 1934, *15*, 438–442.

THE USE OF 200 TO 600 MILLICURIE RADON PACK IN TREATMENT OF MALIGNANT LESIONS*

By W. E. HOWES, M.D.

Attending Radiation Therapist, Brooklyn Cancer Institute, Dr. Ira I. Kaplan, Director

BROOKLYN, NEW YORK

ALL radiologists are familiar with the application of radium molds at from 1 to 10 cm. distance in the treatment of malignant lesions. This method of radium application was used in the Curie Institute by Regaud,[7] who described small radon packs for the treatment of metastases to the lymph nodes in the neck. There is considerable literature relating to the use of radium packs containing 1 to 5 grams of radium element. Such packs are of necessity confined to a very few radium centers, and, because of their great cost, their economic use is questioned, especially with the present development of highly filtered roentgen rays, where the depth dose of the roentgen ray, in many instances, is greater than that delivered by the larger radium pack.

The use of small radon packs is not therefore new, nor are there any new principles of radiation involved. However, we feel that this is a method of treatment which is not employed at the present as fully as it ought to be, particularly in the palliation of extensive malignancies and their metastases somewhere near the surface of the body. When efficaciously applied, this form of treatment will aid in the control of many malignant conditions. Such a method can be used in a great many institutions where only radon is available.

The measurement of the physical factors associated with the administration of a dose of radium at any distance has been worked out accurately by the physicists, so that estimation of dosage can be made with great accuracy in relation to biological reaction. Laurence[4] also worked out the efficiency of certain patterns of radium source with relationship to the skin and depth dose.

In our work, we have employed the results of the findings of Quimby and Pack[5,6] which showed that tissues, having received the limit of tolerance to roentgen radiation, will stand further treatment by gamma rays, and vice versa.

Friedman and Rosh[2] compared the use of roentgen radiation, the large 5 gram radium pack and the 100 mg. radium pack, having particular reference to the treatment of mouth and throat lesions. This stimulated us to attempt irradiation with our small radon pack. Friedman and Rosh state that, using 960 r as the erythema dose for roentgen rays, and 17,500 mg-hr. as the erythema dose for gamma rays, 4.5 S.E.D. with roentgen rays produced the same effect as 3.5 S.E.D. with gamma rays.

The physical basis of our therapy is based on the determination of approximately 8+r in dose equivalent, delivered per milligram-hour at 1 cm. distance, using a filtration of 0.5 mm. platinum.[3] In accordance with the determination of Braestrup[1] we subtracted a loss of 15 per cent in our gamma irradiation due to the addition of 1.5 mm. platinum. The arrangement of the radium in the mold is partly determined by the conformity of the lesion. For our purpose we have employed, in the average condition treated, a block 7 cm. thick × 2 cm. × 5 cm. with four radon tubes placed 3 cm. apart, as shown in Figure 1.

Our estimation of an erythema with this mold, from the above calculations and in accordance with the tables of Stenstrom[8] and Weatherwax,[9] is approximately 9,500 mg-hr. We have clinically tested this factor on the lateral surface of the neck, back and abdomen of several patients. Of course, the intensity varies inversely as the square of the distance, not considering loss of

* Read at the Twenty-first Annual Meeting, American Radium Society, Kansas City, Mo., May 11–12, 1936.

radiation due to absorption and scattering. Our calculations have been made on the basis of four point sources, rather than definitely determining the length and diameter of each individual tube. Figure 2 gives an estimation of a depth dose in such a setup.

When crossfire irradiation is desired from more than one source, each group of 200 mc. is considered as a unit and from one to three such units have been used about an individual lesion. Usually the radon is allowed to depreciate completely on the mold without refilling. However, in one or two individual cases, because of the dose and the time required to deliver it, refilling of tubes with fresh radon has been resorted to.

Calculating the depreciation of radon (one-half being expended in 3.85 days), it is quickly determined that it requires eight days, or 192 hours, to deliver approximately 101 mc-hr. of dose, per millicurie. This was the average duration in the following series of cases, the pack being applied continuously. The pack is firmly applied by bandage and adhesive plaster strapping as shown in the illustrations.

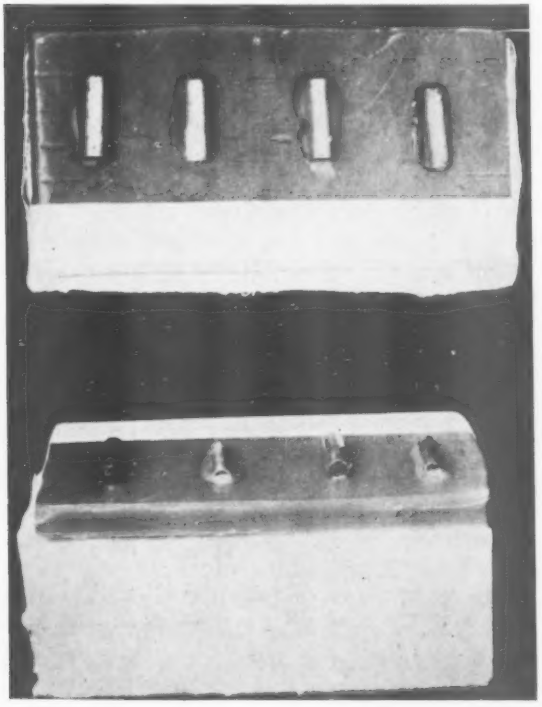


Fig. 1. Photograph of typical 200 mc. pack, showing general relation of platinum tubes.

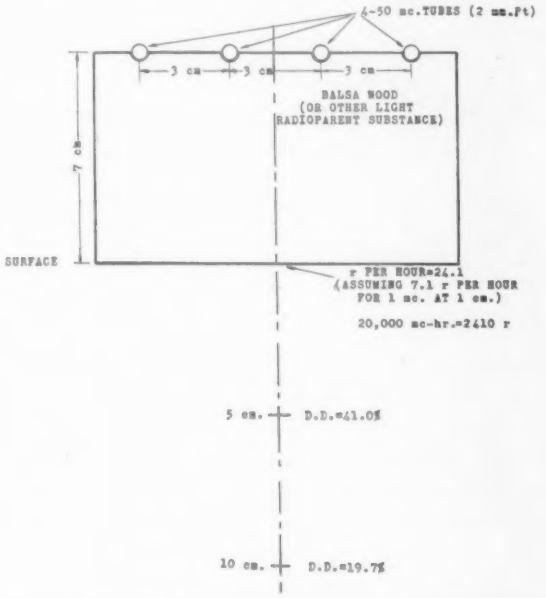


Fig. 2. Graph demonstrating arrangement of pack with calculated depth dose and surface intensity in roentgens per hour.

Friedman, at Bellevue Hospital, has built up a head and neck bandage with adhesive tape which is split, and has added a zipper so that the dressing may be loosened or removed and reapplied with accuracy. Regaud has used wax as the basis of many of his applicators and while this material is quite applicable for molds at 1 to 2 cm. distance, any thicker appliance becomes quite cumbersome and heavy. Using the bandage plus adhesive with a cardboard box or balsa wood plus cotton batting between the skin and dressing, the patient is usually able to tolerate this for as long a period of time as is required to deliver the specified dose.

We have occasionally used lead to help block off the field, or lead rubber to protect an arm. We, however, count most strongly on distance as our greatest protective factor. For instance, in treating a breast or axilla, an attempt is made to place the radium near the angles of the anterior or posterior axillary line, and we also

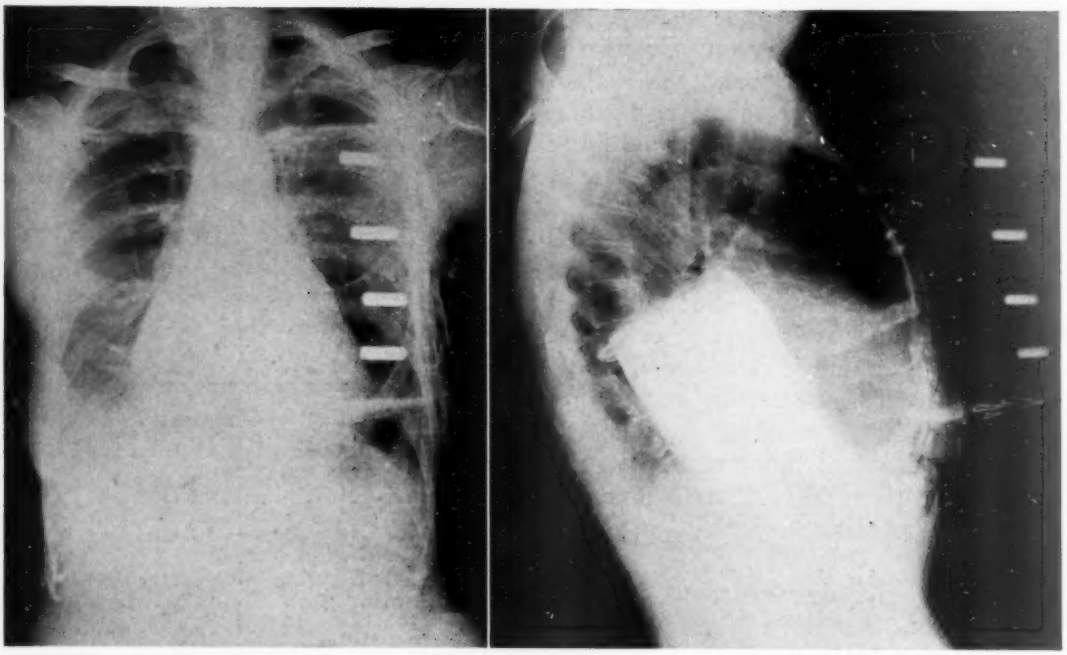


FIG. 3 FIG. 4

FIGS. 3 and 4. Roentgenograms taken at right angles to demonstrate the general relation of the platinum tubes in treating a carcinoma of the breast.

count on the added tolerance of the surrounding normal tissue to the radium, realizing that the tumor mass does not definitely demarcate the extension of the cancer cells beyond the normal. The erythema following the date of application has ranged from thirteen to twenty-five days, usually with an average of three weeks.

The following is a résumé of the clinical results obtained, following the application of such a 7 cm. pack to a series of some 39 cases treated between 1933 and 1935. This does not include cases tested for an experimental erythema:

		Cases
Esophagus—upper third		1
Postoperative prickle cell carcinoma of the temple	Skin	1
Melanoma	Skin	1
Osteogenic sarcoma of femur	Bone	1
Multiple myeloma	Bone	1
Neurofibrosarcoma		1
Carcinoma of the mouth	Floor	9
Carcinoma of the mouth	Tonsil	2
Carcinoma of the mouth	Tongue	2
Carcinoma of the mouth	Alveolus	3
Carcinoma of the breast		17

CASE No. 44365. A. G., female, aged thirty-eight. One of the earliest cases treated and one of the most striking from the standpoint of clinical improvement was a carcinoma involving the upper third of the esophagus. The lesion was of the anaplastic type, producing obstruction by its size, rather than contracture. The patient was admitted on November 9, 1933, having been transferred from another institution, with the chief complaint of dysphagia and regurgitation of solid and liquid food, and as she was in too serious a condition to move from the hospital building to the roentgen therapy service, the radon pack was employed with the hope of accomplishing palliation. She was given treatment with a radon pack at 7 cm., for a total dose of 20,000 mc-hr. to each side of the neck and supraclavicular zone. Skin reaction was severe, with some blistering. Three weeks later the patient was able to swallow a little, eating a rather soft diet; she gained 16 lb. and required no further hospitalization. She lived five months after treatment, until April 7, 1934, when obstruction again developed. Gastrostomy was refused. An autopsy was not permitted.

CASE No. 7525. E. C., female, aged sixty-nine, admitted December 19, 1934, exhibited

recurrence of skin lesion following a rather radical excision of a basal cell and prickle cell type of epithelioma. The operative procedure was attempted in another institution, and following the recurrence, she was transferred to the Brooklyn Cancer Institute for radiation therapy. We first packed the wound with four radon tubes, 1 mm. platinum, for a total dose of 1,000 mc-hr. This was followed one month later with a cycle of roentgen therapy, a total dose of 4,000 r being given to the lesion. The factors used were: 200 kv., 2 mm. copper and 1 mm. aluminum filtration, effective wave length 0.12 Å. While this therapy improved the lesion slightly, there was evidence of persistence of the malignant infiltration over the bone. Six months later a 200 mc. radon pack was applied at 5 cm. distance, for a total of 20,000 mc-hr. While the lesion is still deeply ulcerated, it has improved a great deal following irradiation with the pack. The patient is seen regularly at our clinic. She is comfortable and is listed as improved. The further disposition of this case, however, continues to be a problem.

Case No. 7264. C. B., female, aged forty-seven, admitted August 13, 1934. Diagnosis was melanotic lesion of the temple with metastatic cervical glands. The lesion proved to be greatly radioresistant and unaffected by large doses of roentgen therapy or by a radon pack. She died in August, 1935.

Case No. 55844. D. S., female, aged forty-four, admitted March 9, 1934. Diagnosis was bone sarcoma. She was given a total of 1,700 r to the lesion with no relief of pain or diminution in the size of the lesion. Two radon packs, with a total dose of 20,000 mc-hr., were applied to each area and likewise gave no relief.

Case No. 46298. H. W., female, aged forty-three, admitted in January, 1934. The clinical, roentgenologic and pathological diagnosis was multiple myeloma. She had several pathological fractures of the left femur with malposition of the fragments and malunion. A radium pack at 7 cm. was applied to the left hip to relieve bone pain, for a total dose of 20,000 mc-hr. We felt, however, that the radium pack was of no avail, as she was relieved only by narcotics.

Case No. 7380. G. W., female, aged seventeen, admitted in August, 1933, with a neurofibrosarcoma that arose below the skin of the right shoulder posteriorly. She had had three more and more radical surgical excisions of this mass before she was referred to the radiologist. We first treated the lesion with a total dose of 4,800 r, using a filtered radiation. Two months later three separate packs were applied about the large mass, in the form of a Delta, each pack containing 200 mc. The whole area was crossfired for a total dose of 60,000 mc-hr. Of course, the distance from the center of the mass to the radium units was greater than 7 cm. The distance from the radium source, however, was

Fig. 5. A typical application of the pack for treatment of metastatic cervical glands or carcinoma of the tonsil.

carefully checked at close to 6 cm. An extensive reaction followed, and the tumor responded by dropping down to the skin level with a small ulcerated crater in the center. The lesion was not controlled, however, and the persistent mass was transfixed with radon needles in February, 1936, for a total dose of 3,000 mc-hr. The patient has lost no weight, her condition is good and the lesion has remained confined to the original site—nearly three years.

Case No. 7508. P. W., female, aged seventy-seven, admitted on December 5, 1934, with a prickle cell lesion involving the mucous membrane of the cheek, which had ulcerated through the skin of the cheek. She was given a dose of 2,000 mc-hr. using radon tubes 1 mm. thick applied to the surface. Two months later she received 4,500 r of highly filtered roentgen rays. In January, 1935, because the lesion was spreading rapidly, a dose of 50,000 mc-hr. was given with the pack. The patient never showed any great improvement and died in May, 1935.

FIG. 6 FIG. 7 FIG. 8

FIG. 6. Mode of application of the pack in a breast case. FIG. 7. Recurrent skin metastases following radical mastectomy and previous extensive postoperative roentgen therapy in another institution with result obtained. FIG. 8. Result after treatment with the pack. (Some recurrences have taken place, especially to the other breast, since reading of the paper.)

CASE No. 5957. M. W., male, aged fifty-eight. Syphilis and diabetes complicated this tonsil case which had received at various intervals 4,325, 1,720 and 3,150 r to portals over the neck. He was given a total of 20,000 mc-hr. in one pack, and an additional dose of 15,000 mc-hr. one month later to a different area. He lived but a year.

CASE No. 7241. J. B., male, aged seventy-seven, admitted on August 3, 1934. Clinical and pathological diagnosis was carcinoma of the floor of the mouth, squamous type, with bilateral cervical glands. He received three separate applications of platinum radon tubes to the surface, each 500 mc-hr. In August, 1934, he was given a 7 cm. radon pack to each side of the neck and chin for a total of 20,000 mc-hr. to each side. Following this treatment the lesion in his mouth epithelialized and the glands completely disappeared. One year later the chart showed the mouth lesion marked as healed, but with the appearance of a submental mass. He was sent for custodial care and died on January 27, 1936, of coronary thrombosis.

The above case reports are typical of all of the mouth lesions. All of the cases have died except one tonsil case more recently treated.

CASE No. 8482. E.H., male, aged sixty-two, admitted March 16, 1936. The pathological diagnosis in this case was lympho-epithelioma. At the primary treatment he was given a 7 cm. radon pack for a total dose of 20,000 mc-hr. to each side of the neck. All of the other mouth cases treated had received other types of therapy previous to the application of the radon pack. His present condition, only two months later, is good. The tonsillar ulceration is healed with a clean base, the left submaxillary gland

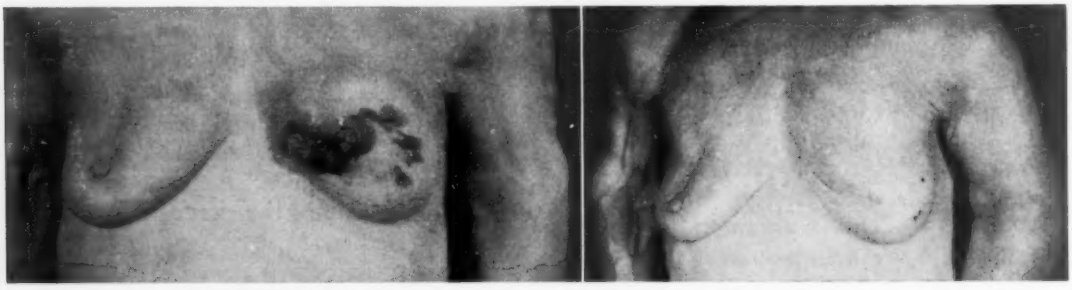


FIG. 9 FIG. 10

FIG. 9. Extensive carcinoma of the breast—the patient is a dwarf—deemed inoperable.
FIG. 10. Result following therapy with the pack.

Fig. 11 Fig. 12

Fig. 11. Extensive ulceration in operative scar following a radical mastectomy.
Fig. 12. Ulcer partially controlled by the pack.

is smaller, he has no pain, swallows without difficulty and is gaining weight.

Likewise all of the breast cases, except 2, have come to us following different types of mastectomy, with either local or general metastases. The unoperated cases were, as can be imagined, most extensive lesions, with skin adherent but not ulcerating. It was in this group of cases that the greatest palliation was effected. Many of the local recurrences involving the cartilage and bone in the chest wall were markedly improved and held under control.

Case No. 7947. M. L., female, aged sixty. This was a postoperative case with extensive skin metastases involving most of the anterior and lateral left chest wall, which had received a great deal of roentgen radiation in an attempt

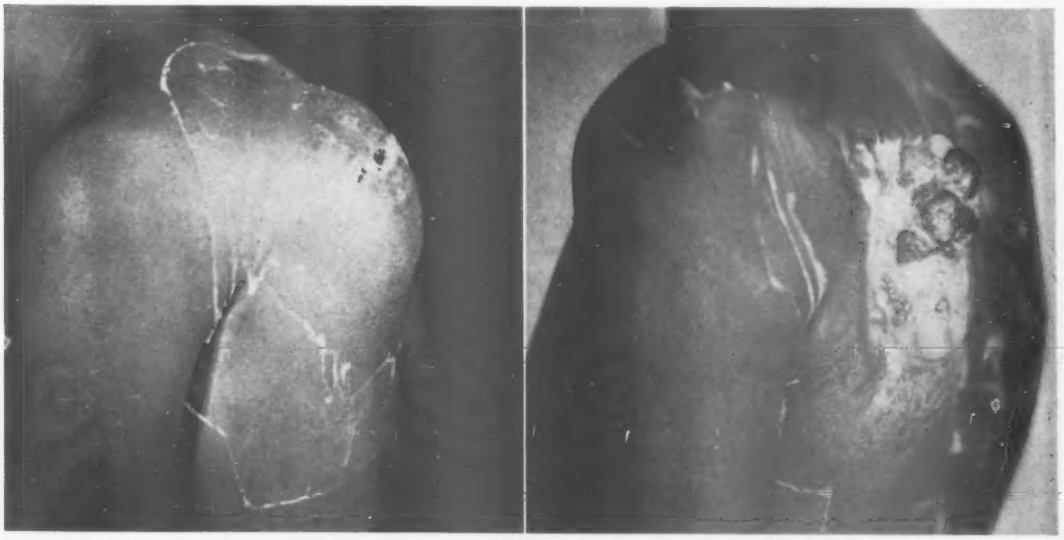


Fig. 13 Fig. 14

Fig. 13. Case No. 7380. Neurofibroma recurrence following three previous attempts at operative removal.
Fig. 14. Case No. 7380. Resultant destruction of mass following application of the pack. (Since the paper was read, the scapula was removed in an attempt to eradicate the process and the patient died with extensive pulmonary metastases.)

to control the lesion in both our institution and others. There was a board-like infiltration of the involved skin. Following the pack application most of these massive indurated lesions disappeared leaving a fairly normal skin. The lesion had, however, extended to the opposite side by cross lymphatic drainage. The patient is now receiving treatment to the other side of the chest.

Many of the breast cases suffer from complications, the most frequent being diabetes and arteriosclerotic heart disease. Eight of the breast cases have died and 7 are being carried along in the clinic as partially controlled. One was transferred to another institution, one discharged with no follow up.

In several of the breast cases we have applied the pack to metastatic areas in bone, and have found the pack well tolerated. Following its application much of the severe pain associated with bone lesions has been alleviated.

SUMMARY

A physical basis for using a 200 mc. model radon pack is given. Estimate of erythema time and depth dose with such a model is noted. Its advantages are listed in that it is economical, labile, tolerated well and clinically efficacious. It can be used after large doses of roentgen radiation. However, the radiologist should guard against overdosage to the skin, and late changes.

REFERENCES

1. BRAESTRUP, C. E. Unpublished paper.
2. FRIEDMAN, M., and ROSH, R. Protracted external irradiation in the treatment of neoplasms of the mouth and throat. *Radiology*, 1935, *24*, 7–15.
3. FRIEDRICH, W., and SCHULZE, R. Neubestimmung der r-Einheit für Gammastrahlen. *Strahlentherapie*, 1935, *54*, 553–569.
4. LAURENCE, G. C. Intensity and dosage near radium needles. *Radiology*, 1935, *25*, 166–181.
5. QUIMBY, E. H., and PACK, G. T. Skin erythema for combinations of gamma and roentgen rays. *Radiology*, 1929, *13*, 306–312.
6. QUIMBY, E. H., and PACK, G. T. Further studies on the skin erythema with combinations of two types of radiation. *Radiology*, 1930, *15*, 30–41.
7. REGAUD, C. Curietherapy of epitheliomata of tongue and of their following adenopathy. *Brit. J. Radiol.*, 1925, *30*, 361–367.
8. STENSTROM, W. Physical factors in teleradium therapy. AM. J. ROENTGENOL. & RAD. THERAPY, 1935, *33*, 296–301.
9. WEATHERWAX, J. L. Physics of Radiology for the Student of Roentgenology and Radium Therapy. Paul B. Hoeber, Inc., New York, 1931, pp. 211–213.

Vol. 37, No. 5

THERAPEUTIC USE OF VARIOUS SOLUTIONS OF RADIUM EMANATION*

PRELIMINARY REPORT

By IRA I. KAPLAN, B.S., M.D.
Director, Radiation Therapy Department, Bellevue Hospital
NEW YORK CITY

THE basis for this work was the idea of applying direct irradiation within the peritoneum to malignancies of the pelvis by means of radium emanation.

Having learned from experience that intensive direct irradiation of a lesion gave best results, we felt that in cases of advanced malignancy of the pelvis, such as carcinoma of the ovary, the malignancy could be directly attacked by injecting radon into the pelvic cavity. We know that air and various solutions have been successfully injected into the pelvis in diagnostic procedures, proving harmless when properly carried out. Analogously, therefore, we deemed it worth while to attempt the injection of radon gas directly into the peritoneum.

For testing out this procedure, we selected an advanced case of ovarian carcinoma, the patient having previously been treated by external roentgen therapy without benefit. With the aid of Carl E. Braestrup, Physicist of the Division of Cancer, there was devised a special syringe in which was inserted the radon capsule, which, when broken, would emit radon into a cylinder whence it would be forced into the peritoneum.

The syringe was constructed in the Physical Laboratory of the Division of Cancer and made as follows:

It consists of a brass cylinder provided with a nozzle at one end where the needle is attached by screw thread. The capacity of the cylinder is 235 c.c. The piston fits air tight to prevent leakage of the emanation, by means of rubber packing. The syringe is used in the following way: Radon glass tubules are placed in the bottom of the cylinder and the tip of the syringe is held below the surface of the liquid to be charged. The piston is then forced completely down to the bottom, thereby crushing the radon tubules and liberating the radon. The piston is then drawn back, sucking in the liquid over the crushed radon seeds. Finally, the piston is forced down again forcing the charged liquid through a filter, thereby preventing any glass from entering through the attached needle into the tissue.

The patient was prepared as for operative paracentesis of the abdomen under sterile conditions. The radon capsule was placed in the firing chamber, the needle was thrust through the abdominal wall into the peritoneal cavity and the radon capsule broken by the pressure screw of the syringe. The plunger was then forced downwards and the air and radon propelled into the peritoneal cavity. Following this procedure the patient was tested electroscopically but to our surprise there was no appreciable evidence of any radon within the pelvic cavity. Apparently, the gas had escaped without entering the patient.

We then considered using a solution containing the gas, which would be a more readily controlled medium for the purpose. Studies and experiments were conducted towards finding a suitable solution which would absorb the radon and act as a vehicle for injection purposes.

Experiment I. Upon deciding to employ solutions rather than the gas, our next procedure was to establish a suitable solution of sufficient potency to react upon tissue. Saline and

* This research was carried on in association with the Laboratory for Experimental Surgery, Dr. Frank CoTui, Director of the Third Surgical New York University Division of Bellevue Hospital, Dr. Arthur M. Wright, Director. Read by title at the Twenty-first Annual Meeting, American Radium Society, Kansas City, Mo., May 11–12, 1936.

TABLE I
SALINE

Hour	Full Solution	1 c.c.
	9.0 mc.	2.0 mc.
3 hr.	6.8 mc.	0.9 mc.
5 hr.		1.8 mc. 1.6 mc.
24 hr.	1.6	0.6 mc.
27 hr.		0.79 mc. 0.8 mc.
30 hr.		0.56 mc.

Ringer's solutions were used at first. Into a test tube containing 10 c.c. of one of these, there was dropped a glass seed holding a predetermined amount of radium emanation. With the aid of a rod, the capsule was easily broken and gas bubbles were seen rising to the surface. Rubber corks were applied. The entire solution and 1 c.c. of decanted amounts were measured for radioactivity immediately and later at hourly intervals.

For the physical determinations, we used a spring electroscope, on one side of which was placed a lead plate. A known standard of radium was used for calibration and to establish the equation $R \times T = C$, where R is the standard, T, the discharge time of the electroscope, and, C, the unknown activity in solution. Tables I and II show the results obtained.

From Tables I and II, Chart I was constructed.

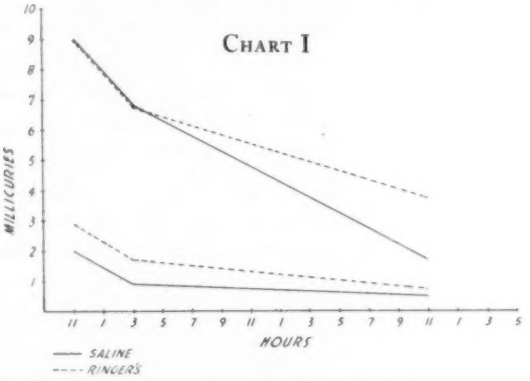
TABLE II
RINGER'S SOLUTION

Hour	Full Solution	1 c.c.
	9.0 mc.	2.9 mc.
3 hr.	6.7 mc.	1.7 mc.
5 hr.		1.7 mc. 1.6 mc.
24 hr.	3.7 mc.	0.8 mc.
27 hr.		0.57 mc. 0.4 mc.
30 hr.		0.3 mc.

Chart 1 clearly demonstrated that the solution is most active immediately after the gas is liberated, and that a progressive decline in activity takes place. This finding is to be expected as a natural phenomenon of radium emanation.

However, it further demonstrated that Ringer's solution has the greater potentiality of holding a slightly higher amount of the gas in solution for a short period of time. The procedure, as outlined, also aided in clarifying a questionable behavior of the gas. It was presumed that a solution which was allowed to

CHART I



stand demonstrated its activity by virtue of the active deposit along the walls of the tube. Also, it was felt that in decanting a prepared solution, any nascent gas would dissipate. The fact that 1 c.c. poured from the original solution was radioactive proved to our satisfaction, first, that the activity was in solution, and, secondly, that it did not evanesce in the process of pouring.

The use of the lead shield on the electroscope warrants a word of explanation. With its use, we were measuring gamma-ray activity. Yet, we appreciate that the biological effects in a radon solution will be mostly from alpha and beta activity. However, since the effects are all directly proportional, we knew the greater the gamma activity, the greater the intensity of the less penetrating rays. Gamma-ray measurements were merely the physical determinations of activity, and thus more inaccurate measurements of the alpha and beta rays were avoided.

Experiment II—Paramecium. Studies were made to determine the effects of the radon solution on low forms of animal life, such as *Paramecium caudatum* and, as a corollary, to establish the minimum lethal dose with the radioactive solution.

Solutions in saline and Ringer's were prepared and diluted from 1:10 to 1:800, and the activity therein contained measured. Solutions with activity above values of 0.025 to 0.03 were found lethal to the organism, while below it no destructive action was observed. The weaker solutions exhibited no apparent deleterious effects upon the organism. Tables III and IV tabulate these findings.

Experiment III. A normal healthy male dog of 20 kilos, of mongrel type, was used for this experiment. Employing the special syringe already described, a solution of 40 mc. in 10 c.c. of normal saline was injected into the peritoneal cavity. There was no immediate reaction. Attempts at measuring the amount of activity within the cavity proved futile because of the sensitivity of our instrument. There was ample evidence, however, that radioactive solution was present within the peritoneum.

Eight days later, the dog was again injected, using 62.8 mc. in 60 c.c. of normal saline. As in the first trial, the solution was made under sterile conditions, and injected at once. Again there was no immediate reaction.

A solution of 140 c.c. of saline with 83 mc. radon was injected nine days after the second test.

Observation. During the course of these injections, the dog behaved normally. There were no manifest ill effects, as evidenced by the continued playfulness and normal appetite. He gained weight during the experiment, and all functions were normal.

Excretory Products. The urine passed during forty-eight hours after each injection was collected and measured at frequent intervals. Similarly, whenever feces were passed, these were measured at once. In none of these excretory products was radioactivity measured.

Table III

PARAMECIUM—ORIGINAL SOLUTION—4.4 MC.

Dilution	Millicurie Content	3 Hours	5 Hours	Result
1:10	4.0	3.7	3.4	Dead
1:100	0.166	0.14	0.12	Dead
1:200	0.13	0.125	0.1	Dead
1:400	0.038	0.03	0.026	Dead
1:800	0.033	0.027	0.021	Alive

Control tests were made in each solution with ordinary *Paramecium* water.

Table IV

Dilution	Millicurie Content	Results
1:1	2.9	Dead
1:10	0.51	Dead
1:100	0.36	Dead
1:200	0.037	Dead
1:400	0.021	Alive

Blood Counts. The blood counts on three different occasions were: polymorphonuclears, 50, 46 and 31 per cent; lymphocytes, 46, 53 and 64 per cent; eosinophiles, 3, 1 and 3 per cent; basophiles, 1, 0 and 2 per cent.

Course. Principally because of mechanical difficulties with our instruments, further injections and measurements were suspended. The dog behaved normally for a while, and then was not observed. He was found dead sixty-two days after the final injection.

Autopsy was performed eighteen hours after death. No abnormal pathology was found in any of the organs. Changes were limited entirely to the omentum and mesentery. Here were found many enlarged glands, in sizes varying from 0.5 to 3 cm. They were hard, discrete, although surrounded with moderate amounts of fat. Their cut surfaces presented varying appearances, from solid, thick, white fibrous masses to spongy hemorrhage.

Microscopic examination of the parenchymal organs was unsatisfactory because of the pronounced degree of post-mortem autolysis. The omentum, however, showed a diffuse fibrosis replacement, along with areas of chronic inflammatory reaction. The one distinct pathological alteration was centered about the smaller blood vessels where increased collagen deposits were found within the lumen and in the vessel wall. These sections were interpreted by Dr. Irving Graef, associate professor of pathology, New York University Medical School.

My thanks are herewith tendered to the several members of my staff who cooperated with me in the carrying out of this work.

THE EVALUATION OF BONE DENSITY IN THE ROENTGENOGRAM BY THE USE OF IVORY WEDGES*

By IRVIN STEIN, M.D.
PHILADELPHIA, PENNSYLVANIA

VERY early in my experience in the study of bone metabolism, it became apparent that there was a distinct need for some fairly accurate method of checking roentgenograms, especially in the evaluation of bone density. Calcification, decalcification or increase in callous formation have never been definitely and accurately determined by the roentgen ray. Inaccuracies occur because of such factors as exposure, line current variation, development, film emulsion and developer deterioration, as well as many others.

Elaborate roentgen-ray equipment, thermostatically controlled solutions, etc., are not always possible and even when thoroughly controlled are subject to some degree of error; for this reason a simple means by which roentgenograms could be standardized so that information concerning changes in density of the image could be obtained appeared desirable.

Oftentimes the roentgenologist, by examination of structure detail in successive roentgenograms, is able to give a helpful opinion as to changes in the architecture of the bone. Evaluation of bone density by visual interpretation of shadow changes must be inaccurate.

There are several methods in use that are designed to aid in providing a more satisfactory comparison of roentgenograms through evaluation of exposure variations. Notable among these methods is the densitometer with the use of step metal strips, usually of aluminum. This is of distinct but limited value since it does not allow an accurate interpretation of bone deposition or absorption because the shadow of the metal steps cannot be interpreted directly in relation to relative amounts of calcium and phosphorus, and also because of the difference in density in the shadow cast by aluminum when different roentgen machines are used.

To check the relative exposures of two films using the density of the outer black parts as a standard is not a feasible procedure, as even a photometer cannot differentiate variations in density in the black areas. Once maximum density has been reached, the density of the outer black parts no longer changes, even to increased exposure. The density of the image does change with increase in exposure, however, until it is blotted out.

It must be borne in mind that any attempt to determine mineralization changes by the roentgen ray must include a series of films taken over a period of time. Any method to be of aid must have some yardstick for measuring changes, regardless of variation in technique in the separate films.

The idea of using ivory as the yardstick appears much more reasonable in dealing with the evaluation of bone changes and of calcification, since the quality of light obtained through the image of ivory is influenced, like that of bone, by an organic framework containing chiefly calcium and phosphorus, the quantity of which can be measured. It not only allows for comparison between the films by comparing the wedges, but also permits comparison of specific areas of bone with definite areas of the wedges.

The first reference to an ivory wedge was that of A. W. Endtz who places ivory disks of known size over the area of bone in which he is interested and ivory disks of varying thickness along the side. By a com-

* From the Department of Orthopedic Surgery of the University of Pennsylvania and from the Philadelphia Orthopedic Hospital.

plicated photo-electric setup he attempts to determine the value of calcium and phosphorus in milligrams.

I feel that this apparatus is rather complex for ordinary use and, though it may well be accurate, it seems that another type of wedge would be simpler.

Another type of wedge was tried by Dr. I. William Nachlas, following the suggestion of Dr. Edward A. Parke. This wedge, prepared under the direction of Dr. Gey, was milled in millimeter steps and this ingenious departure, along the line of the aluminum step-wedge idea, offered a definite method of overcoming some of the difficulties with the straight wedge. It was very small, however, and it had two disadvantages.

In the first place, the steps were very small and only a very small part of each step shadow could be utilized, due to the oblique direction of roentgen rays. In the second place, the method of interpretation was visual and this was inaccurate. An accurate interpretation of the step-wedge shadows or bone shadows must be done objectively with a sensitive instrument such as a photometer.

The wedge described here is but an elaboration of the wedge I saw in the hands of Doctor Nachlas. I believe, however, that this one has proved to be practical and that it represents an improvement over other wedges.

Theoretically, this wedge is not as accurate as that of Endtz and it does not vary much from that of Parke and Nachlas, the difference being only in its size. The steps are built larger and considerably longer. The image of the steps, as well as of certain areas of the image of the bone, is interpreted by a photo-electric cell photometer used with an adequate light source. The photometer values then are plotted on a graph against the steps of the ivory wedge. The steps on this wedge are 9×20 mm.

A fairly simple light source was worked out whereby a powerful beam of light could be shot through the images of the step and any desired area of bone or soft part image, without necessitating the mutilation of the roentgen film. As described above, the light readings obtained by the photometer are plotted on a graph against the step numbers on the wedge. The light value on a bone or soft part image is then plotted on this same graph, and it is very easy to interpret such a value in wedge step numbers. The light value (photometer reading) of the image is plotted directly upon the line obtained by plotting the readings of the wedge from the same plate. Comparison of these lines gives variations in technique. Comparison of the values of the image, plotted on the lines of the graph, gives values in millimeters of ivory and indicates change in bone density.

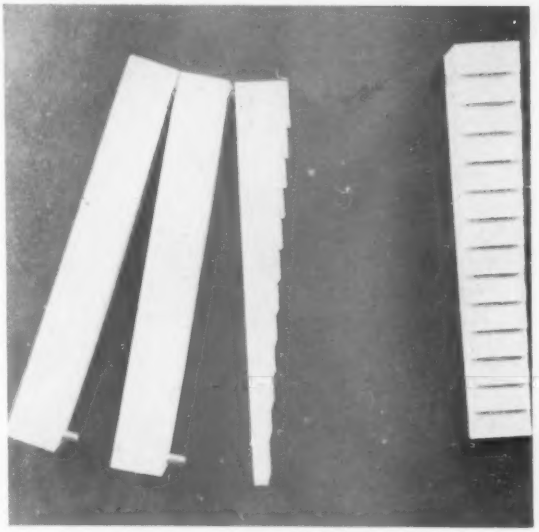


FIG. 1. Ivory step wedges. Upright wedge is milled in 2 mm. steps, thickness ranges from 3 to 29 mm. Wedges on side are 15 mm. thick; milled wedge range is from 4 to 15 mm., 1 mm. steps.

The necessary apparatus is as follows: (1) Ivory wedge of step type, milled in steps of 2 mm. thickness within limits of 0.025 mm. The lower practical limit for routine long bone examination was found to be 3 mm., the upper limit at 30 mm. For adult pelves, femurs and spines, an additional layer of ivory is used to fit under the step wedge and this brings the thickness from 18 to 45 mm. (Fig. 1). (2) Photometer. An adequate photometer was found

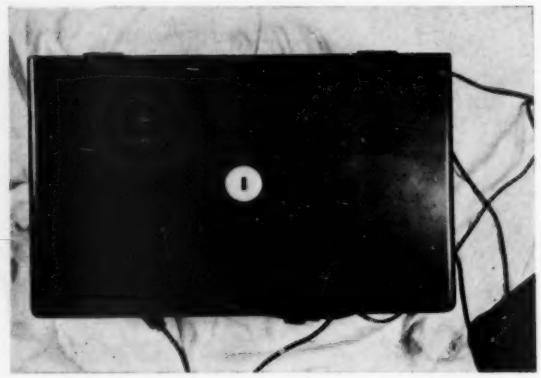


Fig. 2. Box containing light source unit. Light orifice seen in picture measures 6×15 mm.

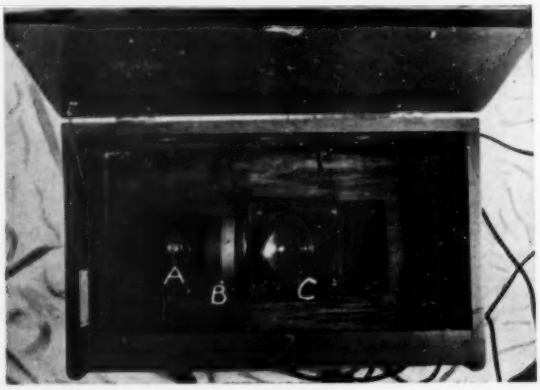


Fig. 3. Light source box open. *A*, 115 volt 100 watt bulb; *B*, 3 inch condenser; *C*, mirror inclined at 45°.

in the ordinary Universal Weston Photometer used in photography. (3) A suitable portable light source. This was easily achieved by using a setup illustrated below. The light source is a small 100 watt 115 volt projection bulb. The condensers are 3 inch condensers mounted in a cell. The light is directed upward by an ordinary glass mirror, set at 45°. The beam of light is picked up by the mirror just before the critical focus and in this way a beam of great intensity and fairly uniform consistency is obtained. A heat glass is placed beneath the slot to prevent burning of the roentgen film, especially on prolonged exposure (Figs. 2 and 3).

When the roentgenogram is taken the wedge is placed along the side of the part to be roentgenographed but at some distance to the side so that no soft part shadow is superimposed on the wedge image. This gives the image of the wedge and the part on the same plate (Fig. 4). Care should be taken in placing the wedge as close to the center of the tube as possible and in subsequent films one should try to duplicate the original positions of the leg (in case the part be the leg), wedge and roentgen tube center. In the case of the leg, the preferred position should be the mid position. For other parts, any position desired may be used, but this must always be duplicated.

It is, of course, understood that the tube distance should be kept constant, as concerns the leg and the film.

The distance between the leg and film should also be kept constant, so, in short, as closely as possible the position of the tube, leg and film should be duplicated. When the film is developed, the image of the ivory wedge will appear upon the film and will be seen as a series of rectangles of increasing density. The roentgen film is

Fig. 4. Roentgenogram showing the shadow of the ivory step wedges and the shadow of a leg.

placed upon the box containing the light source and care is taken to shoot the beam directly through each step. This is not difficult because the aperture is smaller than the step.

A photometer is placed upon the film, over the light beam and the reading is made and charted. The film is slid down to the next step and the same procedure is followed. A graph is then made, the ordinate being the number of steps, the abscissa being the reading of the photometer. Before the readings are made, a reading is made of the unobstructed light beam and the value jotted down. If, on subsequent readings, the value of the unobstructed light is different this can be brought to the same original value by sliding the condenser closer to the light or farther away, depending upon whether or not more or less light is desired.

The completed graph will be similar to that shown in Figure 5. Each curve on the graph indicates the photometer readings of the step wedge for a film. Comparison of the two lines indicates the degree of variation in technique. The plotted points *X* and *Y*, which correspond here to Step 11, are photometer readings for identical areas of bone in two separate plates. Since they give the same step value here, we know there has been no variation in bone density, as is actually the case, since the films plotted were taken of the same leg within a few minutes, but with deliberate change of technique. Suppose, however, that one of the areas had given the reading represented by *Z*, which can be seen on the graph to correspond to Step 10. This would mean difference in bone density aggregating 1 mm. of ivory. Since the lower readings or lower step numbers mean the thinnest part of ivory, Step 10 indicates a 1 mm. decrease in density from Step 11.

It is actually unnecessary to correlate differences in technique, since the ivory wedges always remain unchanged regardless of technique. When the image is interpreted in relation to the wedge, it is interpreted in relation to a constant, and any changes must be assumed to be due to changes in density of the unknown variable.

The method for comparing definite areas of bone to the wedges is as follows:

A caliper measurement is made from a definite point to one or more areas in the bone in question. This is carefully blocked out, using a base line and a side line previously marked through the aid of a caliper, and a reading of this area is made by placing it over the slit in the roof of the light source. Comparison of the light value thus obtained with those of the wedge will locate the step of equal value. It is more accurate if the step readings and the light value of the desired part of the image are plotted upon a graph, because the image value might fall between steps.

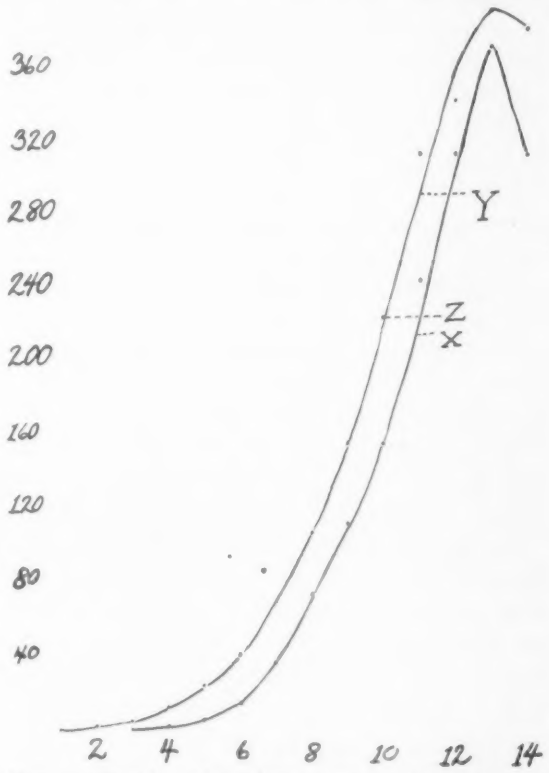


Fig. 5. Graph which shows curves obtained from two plates. Differences in wedge readings indicate difference in technique. Points *X* and *Y* are of the same area of bone indicating no change in bone density. This was actually the case since these films were taken of the same leg within a few minutes.

It is suggested that for bone comparison several areas located from some well-defined point on the bone should be mapped out for that would give an average and would mean greater accuracy in general. For the next comparison film, caliper measurements, from the same point as in the above, are made; the same areas are thereby obtained and interpreted. It must be borne in mind that the possibility of an increase in the diameter of the bone, such as in a growing child, would show increased density without inferring increase in deposition. The wedge, however, determines very small changes, so films of a series can be taken close together to obviate the error from growth.

The apparatus presented here is felt to be accurate to within one-tenth of 1 per cent. This was determined by readings obtained several times through the simple expedient of using the same extremity for making several films within a few minutes of each other but by employing deliberate changes in technique. The readings thus obtained on identical areas of bone correspond to the same step number, even though comparison of the steps indicated variations in technique to a value as great as 4 mm. of ivory. Furthermore, the curves shown in Figure 5 can be seen to be film density curves. The low readings are the under-exposure readings; the high readings, with the drop of the curve, are the over-exposed regions and show reversal of the image.

The apparatus is simple, it can be easily used and involves little more trouble than a marker. It is not expensive and the light source set up for aiding interpretation by the photometer is easily made. The photometer, of course, is easily available and not expensive.*

I wish to express my thanks to Dr. A. Bruce Gill of Philadelphia, Dr. I. Wm. Nachlas, to Baltimore, to Dr. Ralph S. Bromer at the Philadelphia Orthopedic Hospital, and to Dr. E. P. Pendergrass at the University of Pennsylvania Hospital, for their aid and suggestions; and to the Max Levy Co., Wayne Ave. and Berkley for their cooperation in making the ivory wedges and the light source.

REFERENCES

1. Chamberlain, W. E. Personal communication.
2. Endtz, A. W. Een Methode om in vivo het kalkgehalte van het Beenstelsel te Bepalen. N.V. Boek-en Steendrukkerij Eduard Ijdo, Leiden, Holland.

* A water phantom to be used in conjunction with the wedge, to prevent error arising from change in diameter of soft parts, has recently been developed by the author with the cooperation of Mr. S. Reid Warren of the University of Pennsylvania. This provides a method for determining density changes in the pelvis, upper femur, and spine. This will be reported upon in detail at another time.

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Editor: LAWRENCE REYNOLDS, M.D. *Assistant Editor:* RUTH BIGELOW, B.S.

Editorial Board: A. C. CHRISTIE, M.D. E. H. SKINNER, M.D. LAURISTON S. TAYLOR

Advisory Board for Pathology: JAMES EWING, M.D. EUGENE L. OPIE, M.D.

Collaborating Editors: The Officers and Committee Members of the Societies of which this JOURNAL is the official organ, whose names appear on this page, are considered collaborating editors of this JOURNAL.

Foreign Collaborators: A. BÉCLÈRE, M.D., PARIS, GÖSTA FORSSELL, M.D., STOCKHOLM, G. F. HAENISCH, M.D., HAMBURG, R. LEDOUX-LEBARD, M.D., PARIS.

Publisher: CHARLES C THOMAS, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich. Office of publication 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

Officers and Standing Committees

THE AMERICAN ROENTGEN RAY SOCIETY

President: Charles A. Waters, Baltimore, Md.; *President-Elect:* B. R. Kirklin, Rochester, Minn.; *1st Vice-President:* W. E. Chamberlain, Philadelphia, Pa.; *2d Vice-President:* I. H. Lockwood, Kansas City, Mo.; *Secretary:* E. P. Pendergrass, University Hospital, Philadelphia, Pa.; *Treasurer:* E. L. Jenkinson, 1439 S. Michigan Ave., Chicago, Ill.; *Historian:* Percy Brown, 475 Commonwealth Ave., Boston, Mass.

Executive Council: C. A. Waters, B. R. Kirklin, W. E. Chamberlain, I. H. Lockwood, E. P. Pendergrass, E. L. Jenkinson, Lawrence Reynolds, J. B. Edwards, S. W. Donaldson, M. C. Sosman, G. W. Grier, F. M. Hodges, Ross Golden, U. V. Portmann, Carleton B. Peirce, Chairman, University Hospital, Ann Arbor, Mich.

Committee on Hospital Relations: F. O. Coe, Washinton, D. C., A. O. Hampton, Boston, Mass., Sherwood Moore, St. Louis, Mo., H. J. Walton, Chairman, Baltimore, Md.

Committee on Safety and Standards: Edith H. Quimby, New York City, Richard Dresser, Boston, Mass., R. B. Taft, Charleston, S. C., T. Leucutia, Detroit, Mich., Lauriston S. Taylor, Chairman, Washington, D. C.

Publication Committee: H. E. Ruggles, San Francisco, Calif., L. R. Sante, St. Louis, Mo., M. C. Sosman, Chairman, Boston, Mass.

Finance Committee: H. D. Kerr, Iowa City, Iowa, Robert Drane, Savannah, Ga., J. B. Edwards, Chairman, Leonia, N. J.

Advisory Committee to the Moore School X-Ray Laboratory: Karl Kornblum, Philadelphia, Pa., J. H. Vastine, Philadelphia, Pa., Paul A. Bishop, Chairman, Philadelphia, Pa.

Representatives on The American Board of Radiology: L. R. Sante, St. Louis, Mo., B. R. Kirklin, Rochester, Minn., Leopold Jaches, New York.

Delegate to Fifth International Congress of Radiology: Lawrence Reynolds; Alternate, E. P. Pendergrass.

Member, National Research Council: Henry J. Walton, Baltimore, Md.

Editor: Lawrence Reynolds, 110 Professional Building, Detroit, Mich.

Assistant Editor: Ruth Bigelow, 110 Professional Building, Detroit, Mich.

Editorial Board: A. C. Christie, E. H. Skinner, Lauriston S. Taylor.

Advisory Board for Pathology: James Ewing, Eugene L. Opie.

Thirty-eighth Annual Meeting: Chicago, Ill., Sept. 13–17, 1937.

THE AMERICAN RADIUM SOCIETY

President: Zoe A. Johnston, Pittsburgh, Pa.; *President-Elect:* E. H. Skinner, Kansas City, Mo.; *1st Vice-President:* C. L. Martin, Dallas, Texas; *2d Vice-President:* O. N. Meland, Los Angeles, Calif.; *Secretary:* William P. Healy, 121 East 60th St., New York City; *Treasurer:* L. A. Pomeroy, 952 Hanna Bldg., Cleveland, Ohio.

Executive Committee: R. H. Stevens, Chairman, Detroit, Mich., W. H. Cameron, New York City, G. W. Grier, Pittsburgh, Pa.

Program Committee: E. H. Skinner, Chairman, Professional Bldg., Kansas City, Mo.; Hayes E. Martin, New York City, Lyell C. Kinney, San Diego, Calif.

Publication Committee: C. L. Martin, Dallas Texas, J. T. Case, Chicago, Ill., E. P. Pendergrass, Philadelphia, Pa.

Research and Standardization Committee: Maurice Lenz, Chairman, New York City, Wilhelm Stenstrom, Minneapolis, Minn., L. R. Sante, St. Louis, Mo.

Education and Publicity Committee: G. E. Pfahler, Chairman, Philadelphia, Pa., H. H. Bowing, Rochester, Minn., Henry Schmitz, Chicago, Ill.

Advisory Committee on Roentgen-ray and Radium Protection: J. J. Duffy, Chairman, New York City, J. L. Weatherwax, Philadelphia, Pa., W. H. Cameron, New York City.

Janeway Lecture Committee: Curtis F. Burnam, Chairman, Baltimore, Md.

Committee on Arrangements: B. P. Widmann, Chairman, Philadelphia, Pa., W. S. Newcomet, Philadelphia, Pa., B. A. Hughes, Philadelphia, Pa.

Representative on The American Board of Radiology: Rollin H. Stevens, Detroit, Mich.

Twenty-second Annual Meeting: Hotel Chelsea, Atlantic City, N. J., June 7–8, 1937.

EDITORIALS

AUGUSTUS WARREN CRANE
1868–1937

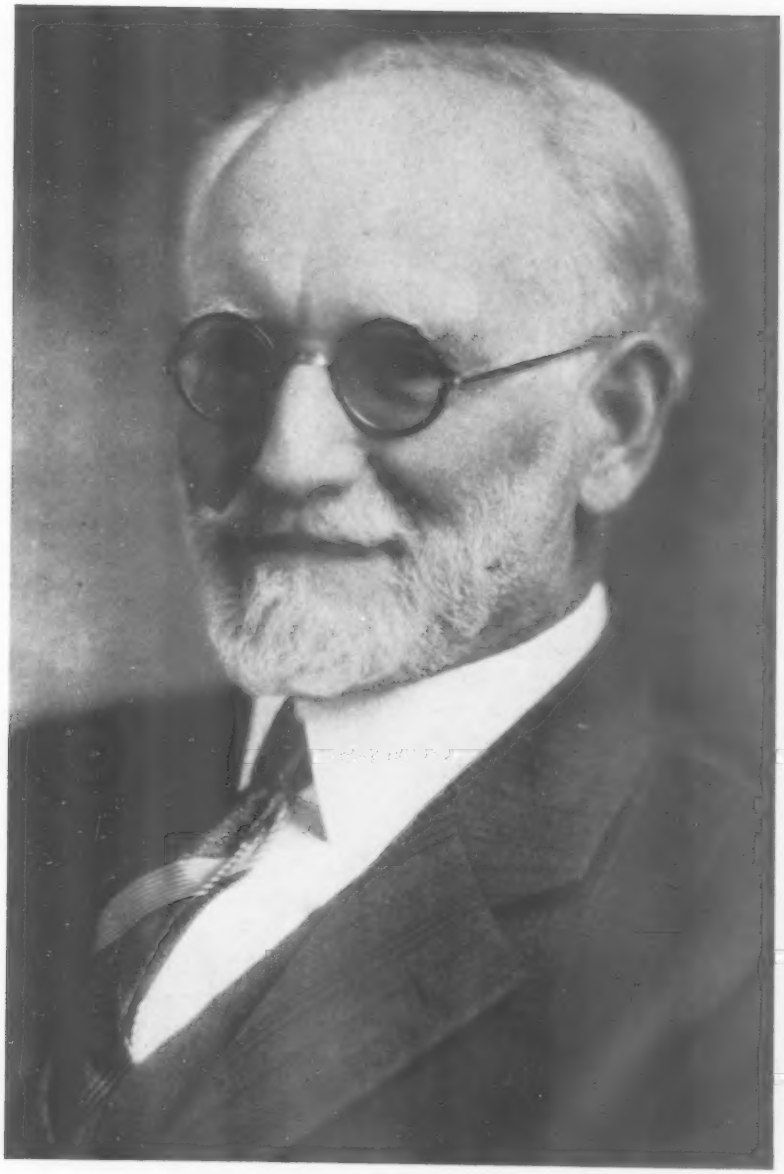
"AFTER this it was noised abroad that Mr. Valiant-for-Truth was taken with a summons by the same post as the other, and had this for a token that the summons was true, that his pitcher was broken at the fountain. When he understood it he called for his friends and told them of it. Then he said: 'I am going to my fathers, and though it is with great trouble I have got thither, yet now I do not repent me of the pains I have been had to arrive where I am. My sword I give to him that shall succeed me in my pilgrimage; my courage and skill to him that can get it. My marks and scars I carry with me to be a witness for me that I have served Him well who now will be my rewarder.' "

Those who knew Augustus Warren Crane, internationally famous in his chosen field of endeavor, cultured gentleman, warm and cordial friend, will instantly sense the appropriate paraphrase of this quotation, and thereby silently render to his memory as a man and a physician a part of the tribute which they know he deserves. And those who did not know him will find an inspiration in the parallel inevitably suggested by his qualities and accomplishments.

For him, however, it was not noised abroad that he was taken with his summons, for it came without warning, and suddenly. But if he could have called for his friends and told them of it, they would have been many. And if he could have bequeathed his equivalents of sword, and courage, and skill, there would have been much.

It is, however, as if he had been thus forewarned and thus disposing; and much more to his liking—for he was modest, with the distinction of the quality of genius, and retiring as to the importance of what he had been able to accomplish. What he was and what he left are an heritage, indeed, and in his passing Radiology has suffered another great loss. Few men in this field have so importantly and favorably influenced a professional specialty. The keen sword of his inquiring and studious mind, and the skill which was always the bright light of his armamentarium, have left a good many important and constructive developments in means, methods and technique. His "marks and scars," however, were mostly the disappointments he found in not being able to pursue, further and further into their hidden reluctances, the "shadows made by invisible light."

Augustus Warren Crane was born in Adrian, Michigan, on November 13, 1868, the son of Nathan Seeley and Julia Etta Chaffee Crane. After attending the Adrian High School and the literary department of the University of Michigan, he graduated from the medical department in 1894, as valedictorian of his class. He immediately afterward established himself in Kalamazoo, Michigan, in the general practice of medicine and surgery. From the beginning he paid special attention to laboratory work, and in 1895 he was appointed city bacteriologist, the first in the State of Michigan. His early medical papers before the Kalamazoo Academy of



AUGUSTUS WARREN CRANE

1868–1937

UNIV. OF MICH.

Medicine dealt with laboratory methods of diagnosis, pathology, and especially with various phases of blood examinations. In 1898 he made an effort to discover the biological meaning of the different blood cells by a study of the blood mammals, reptiles, fishes, birds, worms, crustaceans, and insects, in the course of which he visited many scientific museums for the procurement of blood specimens. These researches were presented in a paper before the Michigan State Medical Society under the title, "Missing Links in the Clinical Examination of the Blood."

Until 1906 he carried on a large general practice and did considerable surgery, while continuing the roentgenological investigations which had interested him from the earliest days of experimentation. After 1906, however, he confined his practice to internal medicine, and after 1915 restricted his work to diagnosis and consultation practice, in which roentgenology became his chief interest.

Dr. Crane had carefully, almost exhaustively, prepared himself for his future in Radiology. Indeed he had already distinguished himself among those who are entitled to be known as "pioneers."

Within three months of Roentgen's first publication he had installed his first x-ray machine—a 12-inch coil operated by a home-made battery and mechanical break (March, 1897). His studies on the matter of interrupters—which, before the day of the interrupterless machine invented by H. C. Snook, by their eccentricities rivaled the gas roentgen tube in the bother they caused the roentgenologist—were crystallized in a lecture at the University of Michigan in March, 1901, describing a method of operating a coil from an alternating circuit by means of an electrolytic interrupter. This lecture led to the general use of the Wehnelt interrupter for running roentgen-ray coils on alternating current.

His earliest and perhaps most notable contribution to the literature of roentgenology was a paper, illustrated by roentgen plates, read before the Kalamazoo Academy of Medicine on September 27, 1898, entitled "The Roentgen Ray in Disease of the Lungs." Under the title "Skiascopy of the Respiratory Organs," this paper was published in the *Philadelphia Medical Journal* of March, 1899. It was received so favorably in England that several medical authors incorporated large parts of it in English textbooks. This was real pioneer work, not sufficiently appreciated by many American workers, although this essay was reprinted in the *American Journal of Roentgenology*, 1916 (Vol. 3, p. 419), for the benefit of students of Roentgenology who had not known of Dr. Crane's valuable early contribution. Readers of this page not familiar with this early pioneering of Dr. Crane will find it instructive to review what was so early accomplished by one man through the sheer force of his own initiative and his brilliant intellect. In this paper he really anticipated most of the roentgenological developments in the study of the chest during the next two decades.

In gastrointestinal work, also, Dr. Crane merits a pioneer's acclaim. His first plates of the stomach and colon were made on December 8, 1905. In March of the following year he read a paper, illustrated with numerous plates, on "The Position and Shape of the Stomach and Intestines during Life." In June, 1907, there followed a paper on "Gastroptosis," and on December 10, 1907, a paper on "Gastric Ulcer." This was also the title of his first paper before the American Roentgen Ray Society, in 1908. The following year he read before the American Medical Association a report on a study of "X-ray Evidence in Gastric Cancer." His early training and interest in the study of the blood were continued in a paper read in 1907 on "Specific Immunity of X-ray Therapeutics," which called attention to the effect of the x-ray in producing an immunity parallel to that produced by vaccines.

In 1915 he read a paper before the

American Medical Association entitled "Roentgenocardiograms," the term "roentgenocardiogram" being coined by him to conform with the term "electrocardiogram." This paper was pioneer work in a line of investigation now being brought to the fore under the name of "roentgen kymography."

Dr. Crane always maintained that the correlation of clinical data with the roentgen findings is the legitimate province of the clinical roentgenologist, and constitutes the main reason for the medical education of the roentgenologist. This is the reason, he insisted, why roentgenology is entitled to the recognition of a full professorship co-equal to the chair of medicine or surgery; why it is entitled to a separate section in the American Medical Association; why its worthy followers should be invested with all the privileges of professional consultation without discrimination from other specialties. He believed that such a practice, while exclusively diagnostic except for roentgen therapy, is not exclusively roentgenological. He called it clinical roentgenology.

And thus—on the record, and from many bases—he may be considered to represent the ideal in a roentgenological specialist, a physician who all along maintained his standing and efficiency as a clinical diagnostician and practitioner of therapeutic radiology while developing superior skill in the application of the roentgen rays to medical problems.

Many honors were accorded Dr. Crane. Early in his career he was made a member of the British Roentgen Society (1899). He was President of the American Roentgen Ray Society in 1916; Caldwell Lecturer in 1932; acting editor of the *American Journal of Roentgenology* in 1917–1918; recipient of the gold medal of the Radiological Society of North America in 1921, for his achievements in the science of radiology; and recipient of the honorary degree of Master of Arts from his alma mater in 1932.

At the time of his honorary degree from the University of Michigan, attention was called to the studied care which marked his written contributions. Gifted with a facility of speech that is rarely the lot even of those whose vocation is to speak from the public platform, he was always able to interest, and hold the attention of, an audience. And possessed of a scientific imagination and a mastery in the use of metaphor, he added interest to any subject on which he essayed to write. His papers were characterized by simplicity and clearness as well as by harmony in his choice of words. A Michigan editor recorded that as a phrase artist he was able to give pen to such expressions (referring to that part of the anatomy immediately above the diaphram) as the "costal grill," "the thoracic cage," "the chest—that one cavity of the body ready-made for roentgen examination." He wrote of one roentgenologist as having "spent the best years of his life on a medical frontier." He wrote of the roentgen ray: "The discovery was unexampled in dramatic surprise and promise." "The miracle of shadows cast by invisible light gave increasing power and precision to diagnosis." "It is the part of the pioneer to brave dangers and hardships. In this far region of the spectrum were lurking unknown dangers, unseen, insidious, deadly."

One of his latest contributions, "The Research Trail of the X-ray," presented at the American Congress of Radiology at Chicago in 1933, revealed the breadth of his investigations. This paper is a classic in roentgenological and scientific literature, and should be treasured by all whose interests center in roentgenology.

Dr. Crane's home life was a happy one. His wife was a distinguished minister of the Gospel and an important figure in state and national life. She preceded him in death by nearly two years. Surviving are two children, a daughter living at home, and a son, Warren Bartlett Crane, who will shortly graduate in medicine from the University of Chicago. Death came to Dr. Crane on the morning of February 20,

1937, at the age of sixty-eight—the final shadow which no science yet has pierced. Shall we pause an instant at the threshold of faith and think of him still at work behind that shadow, trying, perhaps, to read from its other side! We, on this side, shall always remember him as he was, the "delightful and admirable combination of the distinguished scientist, the true scholar, and the fine gentleman."

James T. Case

BIBLIOGRAPHY OF AUGUSTUS W. CRANE

The skiameter. *Phila. M. J.*, 1900, *5*, 32–36.

The relation of municipal laboratories to the control of tuberculosis. *Physician & Surg.*, 1901, *23*, 82–85.

The foundations of faith in medicine. *Phila. M. J.*, 1901, *8*, 323–324.

Skiascopy of the heart. *J. Michigan M. Soc.*, 1903, *2*, 437–439.

Clinical results of high-frequency currents. *Fort Wayne M. Jour.-Mag.*, 1905, 100–107.

Specific immunity and x-ray therapeutics. *Am. J. M. Sc.*, 1908, *135*, 420–426.

X-ray evidence in gastric cancer. *J. Am. M. Ass.*, 1909, *53*, 1962–1964.

Vaccine therapy and a simplified opsonic index. *Am. J. M. Sc.*, 1911, *141*, 724–741.

Clinical factors in x-ray work. *J. Michigan M. Soc.*, 1913, *12*, 263–265.

The stomach as a reflex organ. Am. J. Roentgenol., 1913–1914, *1*, 148.

X-ray examination of the lungs. *J. Michigan M. Soc.*, 1914, *13*, 20–25.

American priority in the use of bismuth for the examination of the human stomach. Am. J. Roentgenol., 1914–1915, *2*, 692–696.

Pulmonary roentgenology. Am. J. Roentgenol., 1915, *2*, 765–770.

Roentgenology of the heart. Am. J. Roentgenol., 1916, *3*, 513–524.

Skiascopy of the respiratory organs. Am. J. Roentgenol., 1916, *3*, 419–430.

Roentgenocardiograms. *J. Am. M. Ass.*, 1916, *67*, 1138–1141.

Use of intensifying screens for skeletal roentgenography. Am. J. Roentgenol., 1918, *5*, 308.

Gastric function following gastro-enterostomy. Am. J. Roentgenol., 1918, *5*, 306.

Pulmonary metastasis. Am. J. Roentgenol., 1918, *5*, 479–482.

Enlargement of the heart. *J. Roentgenol., Iowa City*, 1918, *1*, 325–341.

X-ray methods of determining the size of the heart. *J. Michigan M. Soc.*, 1919, *18*, 1.

Coexisting multiple lesions as causes of diagnostic errors of omission. Am. J. Roentgenol., 1919, *6*, 264–269.

X-ray examination in relation to the general case record. *J. Michigan M. Soc.*, 1920, *19*, 245–248.

Behavior of the stomach in ulcer and cancer of the duodenum below the bulb. Am. J. Roentgenol., 1922, *9*, 102–111.

Duodenal bulb deformity in relation to symptoms and the chemistry of the gastric juice. *J. Radiol.*, 1922, *3*, 218–221.

The roentgenological aspects of achylia gastrica. Am. J. Roentgenol., 1922, *9*, 527–530.

The roentgenological aspects of the visceral crises. *J. Radiol.*, 1923, *4*, 85–87.

——, with Warthin, A. S., and Jackson, J. B. Pigmentation of the skin (Addison's disease) associated with lymphosarcoma involving particularly the retroperitoneal lymph nodes of the solar plexus region. *Arch. Dermat. & Syph.*, 1924, *10*, 139–162.

Roentgenological sign of mucous colitis. Am. J. Roentgenol. & Rad. Therapy, 1927, *17*, 416–425.

Extra-abdominal affections giving gastro-intestinal symptoms, with special reference to Ménière syndrome. *Radiology*, 1928, *11*, 447–452.

——, with Caldwell, G. H. Influence of phenolphthalein in intestinal movements. *Radiology*, 1929, *13*, 403–412.

Preston M. Hickey 1865–1930. Am. J. Roentgenol. & Rad. Therapy, 1931, *25*, 145–150.

X-ray diagnosis of peptic ulcer. *J. Michigan M. Soc.*, 1931, *30*, 487–490.

Gallstone obstruction of duodenum, with sinus between gallbladder and duodenal bulb. Am. J. Roentgenol. & Rad. Therapy, 1931, *26*, 92–95.

Preston M. Hickey, pioneer in roentgenology. Am. J. Roentgenol. & Rad. Therapy, 1932, *27*, 110–112

Roentgen-ray findings and clinical background; Caldwell lecture, with introduction by J. T. Case. Am. J. Roentgenol. & Rad. Therapy, 1932, *28*, 579–593.

Francis Hauksbee; did he, in 1709, see his hand through sealing-wax and pitch? With repetition of experiments. Am. J. Roentgenol. & Rad. Therapy, 1933, *29*, 671–687.

Research trail of x-ray. *Radiology*, 1934, *23*, 131–148.

Education of Frank Andrews. *J. Michigan M. Soc.*, 1935, *34*, 19–26.

JAMES J. QUINEY
1881–1937

DR. James J. Quiney died of coronary thrombosis on March 31, 1937, at his home in Easton, Pennsylvania. By his untimely end, Radiology suffers a sad loss, his numerous colleagues a steadfast friend, and the community a highly respected and honored citizen.

Dr. Quiney was born in Camden, New Jersey, July 31, 1881. He received his early education in the public schools and the South Jersey Institute, Bridgeton, New Jersey. He then entered the Jefferson Medical College from which he was graduated in 1903. For many years he engaged

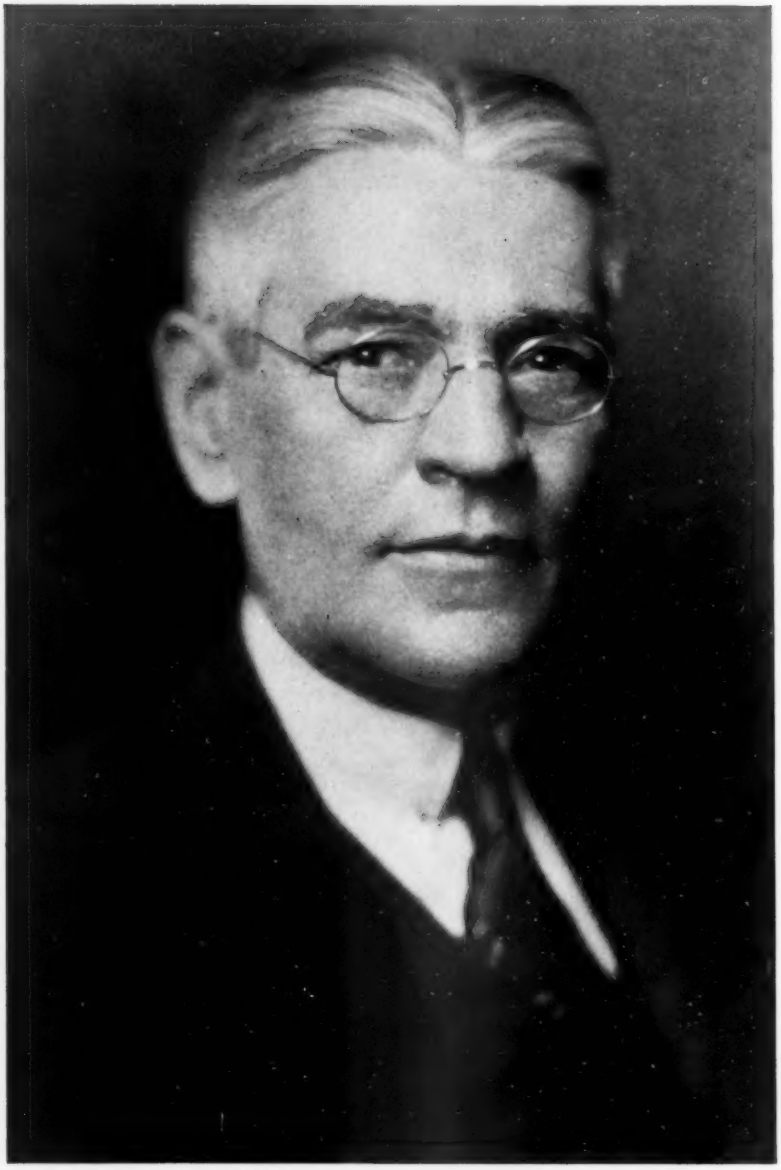
in private practice of radiology in Easton Pa., holding the position of Radiologist to the Easton Hospital, and for a time a similar appointment to the Warren Hospital, Phillipsburg New Jersey.

He was elected to membership in the American Roentgen Ray Society in 1919. At the time of his death he was a Fellow of the American College of Radiology and also of the College of Physicians of Philadelphia, a member of the Radiological Society of North America, the Lehigh Valley Medical Society, the Pennsylvania State Medical Society and the American Medical Association. The recognition of the esteem in which he was held is shown by the fact that he was past president of his County Medical Society, of the Philadelphia Roentgen Ray Society, and of the Pennsylvania Radiological Society.

Dr. Quiney was an indefatigable worker. With the exigencies of a busy practice he found time to contribute often to the programs of the various societies of which he was a member and to be most active in promoting the highest ethical and scientific standards of his specialty in his community and state. His friends were numerous. His kind and jovial temperament, his tact, his helpful advice and counsel to his younger colleagues, his ability to think clearly and to reach conclusions based on a wide clinical experience, made him a valued member of his medical organizations and a respected and admired associate. His was an untiring energy, devoted to the best interests of his chosen field of work. His passing in the prime of life, with many years of useful and continued endeavor and accomplishment ahead of him, leaves a great gap in the life of his community and profession.

He is survived by his wife, Pearla N. Quiney, two daughters, Mrs. Elizabeth I. Lerch and Pearl Ann, and a son, James J. Quiney, Jr. who is completing his second year in the Jefferson Medical College.

Ralph S. Bromer



ROBERT BATTEY GREENOUGH
1871–1937

ROBERT BATTEY GREENOUGH, distinguished surgeon and contributor to the better diagnosis and treatment of cancer, died suddenly of coronary disease in Boston on February 16, 1937.

Dr. Greenough was born in Cambridge, Massachusetts, November 9, 1871, the son of James Bradstreet and Mary Battey Greenough. He prepared for college at Hopkinson's School in Boston from which he entered Harvard University, receiving the degree of A.B. *cum laude* in 1892. He then entered Harvard Medical School from which he was graduated in 1896 with the

degree of M.D. *cum laude*. He was surgical house pupil, on the East Surgical Service, at the Massachusetts General Hospital from August 1, 1895, to December 1, 1896, followed by a short appointment on the West Medical Service after which he went abroad to study pathology in Göttingen and Vienna. On returing to Boston he became associated with Dr. John Collins Warren, then at the peak of his brilliant surgical career. Without doubt, Dr. Warren's interest in cancer materially influenced the life work of his able apprentice.

During his entire professional life he was associated, in some capacity, with the Massachusetts General Hospital, to which he gave a long and valuable service, being appointed as Surgeon to the Out-Patient Department, June 1, 1900; Assistant Visiting Surgeon, August 1, 1911; Visiting Surgeon, February 2, 1916; and Board of Consultation, February, 1932. This institution gave him the opportunity for carrying out many of his ideals. Here he developed the first "Tumor Clinic" which has been extensively copied throughout the world and undoubtedly is a permanent feature in the hospital management of this group of patients.

Dr. Greenough was appointed Assistant in Surgery at the Harvard Medical School in 1901; Instructor in Surgery in 1905; and Assistant Professor in Surgery in 1910; the latter position he held until his retirement from active service at the Massachusetts General Hospital in 1932. He was an inspiring teacher, much beloved by his students.

He served as a member of the Cancer Commission of Harvard University for many years and was active in the organization of the Collis P. Huntington Memorial Hospital. He was appointed Surgeon-in-Chief of this Institution in 1915 and held this position for many years, retiring when he became a member of the Consulting Staff. His long association with, and knowledge of, the cancer problem made him the logical person to cooperate with the late Dr. George H. Bigelow, then Commissioner of Public Health, in the organization of the Massachusetts State Hospital for the Treatment of Cancer at Pondville. The success of this venture is now recognized.

In March, 1915, he went to France with the first Harvard Unit as Surgeon and Executive Officer, serving three months in the American Ambulance at Neuilly-sur-Seine. Two articles which he wrote following this experience were of great help to the medical profession in this country just prior to our entry into the war. Being in the Naval Reserve Corps, he was ordered to active duty in the United States Navy on July 28, 1917, as Chief of the Surgical Service of the Chelsea Naval Hospital. He began this service with the rank of Lieutenant, Junior Grade, and rose to the rank of Commander, U.S.N.R.F., Class 4, being relieved of active duty on February 3, 1919.

He was an active worker in the Massachusetts Medical Society, and a councillor for many years, and was President of this organization from 1929 to 1931.

He was a staunch supporter of the American College of Surgeons, serving this organization on the Board of Governors from 1923 to 1925; as Regent from 1924 to 1937. During this latter time, he was a member of the Executive Committee. He was President of the College in 1934–1935 and was Vice-Chairman of the Board of Regents and the Executive Committee at the time of his death. He contributed a great deal to the cancer program of the College as well as to its other routine activities.

He was a Director of the Society for the Control of Cancer, and was President of this body from 1936 to 1937. He was an active member of the American Association for Cancer Research; the American Surgical Society; the Academy of Arts and Sciences; the American Radium Society; the Society of Clinical Surgeons; the New England Surgical Society; and the Boston Surgical Society, having served

as President of this organization from 1928 to 1930.

Dr. Greenough made over sixty contributions to the medical literature; the greater part of these were on some phase of malignant disease. He leaves an unfinished monograph on the subject. In 1936, he was appointed a member of the Board of Managers of the Memorial Hospital for the Treatment of Cancer and Allied Diseases in New York City. At the request of Secretary Frances Perkins, he accepted an appointment on the Medical Advisory Committee on Social Security, devoting a great deal of time and thought to the problems involved.

Dr. Greenough's life was an active one devoted to duty and humanity. Through his skill as a physician and surgeon he did much to relieve and comfort that large group of patients suffering from malignant disease. His ability as an organizer and executive was outstanding. The clinics and institutions for the study and care of the cancer patient, which he helped to establish, are a lasting tribute to his memory. In the midst of his many professional activities he found time to develop a large group of real friends who will continue to miss him in the clinic and in the council chamber as the days pass.

GEORGE W. HOLMES

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. E. P. Pendergrass, University Hospital, Philadelphia, Pa. Annual Meeting: Chicago, Ill., Sept. 13–17, 1937.

American College of Radiology
Secretary, Dr. E. L. Jenkinson, 1439 S. Michigan Ave., Chicago, Ill. Annual meeting: Chicago, Ill., September, 1937.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: Atlantic City, N. J., June 9–11, 1937.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N.Y. Annual meeting: Chicago, Ill., Sept. 13–17, 1937.

Radiological Section, Baltimore City Medical Society
Secretary, Dr. Howard H. Ashbury, Baltimore. Meets third Tuesday each month, September to May.

Radiological Section, Connecticut State Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets annually in May. Special meetings may be called by the Chairman.

Radiological Section, Los Angeles County Medical Society
Secretary, E. N. Liljedahl, Los Angeles, Calif. Meets on the second Wednesday of each month at the County Society Building.

Radiological Section, Southern Medical Association
Secretary, Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. E. Mendelson, 120 E. 19th St., Brooklyn, N. Y. Meets monthly on first Tuesday, October to April.

Buffalo Radiological Society
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

Chicago Roentgen Society
Secretary, Dr. R. G. Willy, 1138 N. Leavitt. Meets second Thursday of each month October to May inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. H. G. Reineke, General Hospital Cincinnati, Ohio. Meets third Monday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. North W. Shetter, 14600 Detroit Ave. Meetings are held at 6:30 P.M. at the Cleveland Chamber of Commerce Club rooms on the fourth Monday of each month from October to April, inclusive.

Denver Radiological Club
Secretary, Dr. N. B. Newcomer, 306 Republic Bldg., Denver, Colo.
Meets on the third Tuesday of each month.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne Country Medical Society Building.

Florida State Radiological Society
Secretary, Dr. Harold O. Brown, Tampa, Florida. Meetings held twice a year, May and November.

Illinois Radiological Society
Secretary, Dr. Cesare Gianturco, 602 W. University Ave., Urbana, Ill. Regular meetings held quarterly.

Indiana Roentgen Society
Secretary, Dr. C. C. Taylor, Indianapolis, Ind. Meeting held the second Sunday in May annually.

Long Island Radiological Society
Secretary, Dr. S. G. Schenck, 115 Eastern Parkway, Brooklyn, N.Y. Meets at Kings County Med. Soc. Bldg. on third Thursday of each month from October to May, at 8:30 P.M.

Michigan Association of Roentgenologists
Secretary, Dr. C. S. Davenport, St. Lawrence Hospital, Lansing, Mich. Three meetings a year, Fall, Winter, and Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. S. A. Morton, Columbia Hospital, Milwaukee, Wis. Meets monthly. Place of meeting named by the president.

Minnesota Radiological Society
Secretary, Dr. L. G. Rigler, University Hospital, Minneapolis, Minn.

Nebraska State Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets third Wednesday evening of each month.

New England Roentgen Ray Society
Secretary, Dr. E. C. Vogt, 300 Longwood Ave., Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. P. S. Avery, New Brunswick, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by the president.

New York Roentgen Society
Secretary, Dr. R. W. Lewis, 140 E. 54th St., New York. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse, N. Y. Three meetings a year—January, May, and November.

Pacific Roentgen Club
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, Williamsport, Pa. Two day annual meeting will be held Friday and Saturday, May 21 and 22, 1937, Hotel Lawrence, Erie, Pa.

Philadelphia Roentgen Ray Society
Secretary, Dr. B. R. Young, Temple University Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Camp C. Thomas, 476 Lake Ave. Meets on second Thursday from October to May, inclusive, 8 P.M., Rochester Academy of Medicine Building.

St. Louis Roentgen Ray Society
Secretary, Dr. P. C. Schnoebelen, Missouri Bldg., St. Louis, Mo. Meets first week of each month. Time and place of meetings designated by president.

South Carolina X-Ray Society
Secretary, Dr. R. B. Taft, 105 Rutledge Ave., Charleston. Meets at time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

TEXAS RADIOLOGICAL SOCIETY
Secretary, Dr. M. H. Glover, 414 Hamilton Bldg., Wichita Falls, Texas. Meets twice a year. Mid-year meeting on opening day of Texas State Medical Association, Fort Worth, May 10, 1937.

UNIVERSITY OF MICHIGAN DEPARTMENT OF ROENTGENOLOGY STAFF MEETING
Secretary, Dr. C. B. Peirce, University Hospital, Ann Arbor, Mich. Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

UNIVERSITY OF WISCONSIN RADIOLOGICAL CONFERENCE
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

VIRGINIA ROENTGEN RAY CLUB
Secretary, Dr. V. W. Archer, University Hospital, University, Va.
Meets annually in October.

CUBA

SOCIEDAD CUBANA DE RADIOLOGIA Y FISIOTERAPIA
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

BRITISH EMPIRE

BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE RÖNTGEN SOCIETY
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1, or as advertised.

SECTION OF RADIOLOGY OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine, 1, Wimpole St., London, W. 1.

SECTION OF RADIOLOGY AND MEDICAL ELECTRICITY, AUSTRALASIAN MEDICAL CONGRESS
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

RADIOLOGICAL SECTION OF THE VICTORIAN BRANCH OF THE BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to Nov. incl. for scientific discussions.

SECTION ON RADIOLOGY, CANADIAN MEDICAL ASSOCIATION
Secretary, Dr. A. C. Singleton, Medical Arts Bldg., Toronto 5, Ontario.

RADIOLOGICAL SECTION, NEW ZEALAND BRITISH MEDICAL ASSOCIATION
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch. Meets annually.

CONTINENTAL EUROPE

BELGIAN SOCIETY OF ROENTGENOLOGY
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

SOCIEDAD ESPAÑOLA DE RADIOLOGIA Y ELECTROLOGIA
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7, Madrid, Spain. Meets monthly in Madrid.

SOCIÉTÉ DE RADIOLOGIE MÉDICALE DE FRANCE
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

SOCIÉTÉ SUISSE DE RADIOLOGIE (SCHWEIZERISCHE RÖNTGEN-GESELLSCHAFT)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

SOCIÉTÉ FRANCAISE D'ELECTROTHÉRAPIE ET DE RADIOLOGIE MÉDICALE
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

ASSOCIATION OF GERMAN ROENTGENOLOGISTS AND RADIOLOGISTS IN CZECHO-SLOVAKIA
Secretary, Dr. Walter Altschul, German University, Prague, II.52.

DEUTSCHE RÖNTGEN-GESELLSCHAFT (GESELLSCHAFT FÜR RÖNTGENKUNDE UND STRAHLENFORSCHUNG)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

SÜD- UND WESTDEUTSCHE RÖNTGENGESELLSCHAFT
Meets annually in different cities.

NORD- UND OSTDEUTSCHE RÖNTGENGESELLSCHAFT
Meets annually in different cities.

DUTCH SOCIETY OF ELECTROLOGY AND ROENTGENOLOGY
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

SOCIETA ITALIANA RADIOLOGIA MEDICA
Secretary, Professor M. Ponzio, University of Turin, Turin.

SOCIETATEA ROMANA DE RADIOLOGIE SI ELECTROLOGIE
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania.
Meets second Monday in every month with the exception of July and August.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson, Meets annually.

LENINGRAD ROENTGEN RAY SOCIETY
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

POLISH SOCIETY OF RADIOLOGY
Secretary, Dr. Jan. Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

WARSAW SECTION, POLISH SOCIETY OF RADIOLOGY
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

SCANDINAVIAN ROENTGEN SOCIETIES
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

SOCIETY OF MEDICAL RADIOLOGY IN SWEDEN
Meets in Stockholm.

SOCIETY OF MEDICAL RADIOLOGY IN NORWAY
Meets in Oslo.

SOCIETY OF MEDICAL RADIOLOGY IN DENMARK
Secretary, Dr. G. Biering, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

SOCIETY OF MEDICAL RADIOLOGY IN FINLAND
Meets in Helsingfors.

VIENNA ROENTGEN SOCIETY
Meets first Wednesday of each month, at 6.30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

ORIENT

JAPAN X-RAY ASSOCIATION
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

KINKI ROENTGEN-ABEND SOCIETY
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

MEMORIAL MEETING FOR DR. SHEARER

A Memorial Meeting for the late John S. Shearer, Ph.D. was held at the New York Academy of Medicine on Monday evening, April 19, 1937. Dr. F. K. Richtmyer, Professor of Physics at Cornell University, delivered an address on the "Absorption of High Voltage Roentgen Rays." Dr. Larkin of Ithaca, N. Y., and Dr. Christie of Washington, D. C., gave talks on the life and work of Dr. Shearer.

MEMORIAL MEETING FOR DR. MANGES

On Thursday evening, April 1, 1937, the Philadelphia Roentgen Ray Society held a Memorial Meeting for the late Dr. Willis F. Manges, at the College of Physicians, Philadelphia. The following program was presented.

1. Resolution of the Philadelphia Roentgen Ray Society on the Death of Willis Fastnacht Manges. Read by Dr. Barton Young, Secretary.
2. Light. By Dr. Leon Solis-Cohen.
3. The Roentgen Treatment of Infections. By Dr. Richard Manges Smith.
4. Contributions of Dr. Willis F. Manges to Bronchoscopy. By Dr. Chevalier Jackson.
5. Willis F. Manges, The Chief. By Dr. John T. Farrell, Jr.
6. Early Reminiscences of the Philadelphia Roentgen Ray Society. By Dr. William S. Newcomet.
7. Presentation of the Manges Portrait. By Dr. George E. Pfahler.

The poem by Dr. Leon Solis-Cohen dedicated to Dr. Manges is reprinted here by the permission of Dr. Solis-Cohen:

LIGHT

Of what avail Death's summons to lament,
Yet question we the wisdom of the blow;
Azrael might have spared him did he know
With less than Truth, he never was content.
He needs no meed of praise our lips allow,
Nor can his spirit to our sorrow thrill;
But there remains what Death can never still,
Enduring fame that rests upon his brow.
His teachers I have heard his lips acclaim,
At the altar of his works his pupils kneel;
Master, it is full time that we reveal
The light from which our candles draw their flame.

BOOK REVIEWS

Books Received Are Acknowledged under Heading: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers as space permits.

THE 1936 YEAR BOOK OF RADIOLOGY. Diagnosis: edited by Charles A. Waters, M.D., Associate in Roentgenology, Johns Hopkins University; Assistant Visiting Roentgenologist, Johns Hopkins Hospital; Associate Editor: Whitmer B. Firor, M.D., Assistant in Roentgenology, Johns Hopkins University; Assistant in Roentgenology, Johns Hopkins Hospital. Therapeutics: edited by Ira I. Kaplan, B.Sc., M.D., Director, Division of Cancer, Department of Hospitals, City of New York; Director, Radiation Therapy Department, Bellevue Hospital, New York City, etc. Cloth. Price, $4.50. Pp. 604, with 616 illustrations. Chicago: The Year Book Publishers, Inc., 1936.

This Year Book of 1936 need not surpass the others to be worthy of the consideration of everyone interested in radiology or in scientific medicine. In the months since its issue it has proved its value in our daily practice and we venture to say in the libraries of all established radiologists. For those just now entering or contemplating entrance into this field we cannot too strongly commend it.

In interest as well as general make-up it seems to surpass those of previous years. Such a book presents a hard task for the reviewer. Each article contains so much of concentrated fact illuminated or evaluated by appropriate comments of the editors that it is difficult to select the "high lights" of the book. We note that the publisher's description lists some fifteen or twenty subjects of especial note in each section but this is a meager representation of the 477 selections from the thousands of contributions to literature at the authors' command. Tomography, seminal vesiculography and such subjects are of interest because of their relative newness, but few of the older subjects are so well understood that no light can be thrown on them.

Numerous rare and unusual cases are well illustrated in this volume to a greater extent, we believe, than in previous works.

In the therapeutic section Ewing's conception of cancer is an authoritative statement of the best scientific thought on the subject. This is but one of the articles in the symposium on the general nature of cancer—all of which are well worth reading. Therapy of cancer is given its usual large place in the book but the very important work being done in treatment of specific and nonspecific infections of various degrees of chronicity is well covered. Numerous reports on the use of supervoltage published during the past year are summarized, the editor wisely advising caution in too early conclusions about their relative value.

This is an Herculean task—to select the most useful and important parts of the literature and those which are scientifically sound or denote progress and distinguish them from the fads or results of superficial thinking. We, the readers, should realize our great privilege in enjoying at our leisure the fruits of their labor.

We hope that Drs. Waters and Kaplan will find it possible to continue in the years to come their most valuable contribution to the advancement of science and to the efficiency of service rendered by radiologists to their patients.

E. WALTER HALL

AN INTRODUCTION TO DERMATOLOGY, with a Chapter on the Theory and Technique of X-Ray and Radium Therapy. By E. H. Molesworth, M.D., Ch.M. (Sydney), Lecturer in Diseases of the Skin, University of Sydney; Lecturer in Diseases of the Skin, School of Public Health and Tropical Hygiene, Sydney; Member of the Faculty of Medicine, University of Sydney; Senior Honorary Physician for Diseases of the Skin, Royal Prince Alfred Hospital, Sydney; Honorary Dermatologist, Prince Henry Hospital, Sydney, etc. Cloth. Price, 25s. Pp. 520, with 151 illustrations in the text and references to the colored plates of Jacobi's Dermochromes and Semon's Atlas of the Commoner Skin Diseases. London: J. & A. Churchill, Ltd., 1937.

An examination of this book gives the reviewer (who is not a dermatologist), the im-

pression that the author has exercised unusual care and fine discrimination in its production. By the elimination of superfluous material, orderly arrangement, and careful choice of language he has produced a work which is much more comprehensive than its title and size would indicate.

The impression is further gained that although the author has due respect for the views of others he also has a mind of his own which is unobtrusively and yet convincingly revealed throughout the text. This adds much to its interest.

Irradiation, which occupies so large a place in the treatment of skin diseases, is adequately discussed both from the physical and therapeutic standpoint and is thoroughly up-to-date. The author's teaching with respect to irradiation is, in the main, along orthodox lines, but there is in it an element of novelty which should prove to be wholesomely provocative. Those who believe that the utility of radium as compared with roentgen rays is becoming more and more restricted will find pleasing confirmation of their views. For instance, in the treatment of hemangioma, the author expresses strong preference for the latter.

In the section devoted to malignant diseases, the author expresses apprehension lest the doses of radiation which he recommends in their treatment be considered too large. American radiologists are apt to feel that his apprehension might more appropriately have taken the contrary direction. This may be because the radiologist habitually sees more of the disabling, life-destroying forms of malignant disease than does the dermatologist.

As a text for students, and for physicians generally who wish to "brush up" on dermatology, this book is highly recommended. Dermatologists and radiologists will find it stimulating and interesting.

Thomas A. Groover

The Human Foot: Its Evolutionary Development, Physiology and Functional Disorders. By Dudley J. Morton, Associate Professor of Anatomy, College of Physicians and Surgeons, Columbia University. Cloth. Price, $3.00. Pp. 244, with 100 illustrations. New York: Columbia University Press, 1935.

No one knows better than the physician how inadequate is his knowledge of the cause and correction of disorders of the human foot. In fact, the average physician, like the average man, has foot disorders of his own or in his immediate family which he would like to understand and cure.

The author points out that the care of foot disorders is now chiefly outside the medical profession, i.e., with chiropodists and shoe men, the latter class being for the most part without adequate knowledge and training or imbued with a commercial instinct which exploits the corrective features of their shoes—not based on a genuine understanding of the condition to be corrected.

Dr. Morton's book makes a scientific as well as a very interesting approach to the foot problem through the evolutionary history of its structure and development. The origin of the vertebrate limbs and the gradual change in number, contour and relation of the bones as the primates, anthropoids, and finally man, are considered, furnishes absorbing reading for the lay as well as the medical scientist.

The function of the foot, in relation to center of weight bearing, balance, stability, propulsion and locomotion are clearly discussed and a thorough groundwork laid for the clinical observations in the later chapters of the book.

He develops his principles so logically and clearly that the final principles of diagnosis and treatment are naturally accepted—even in his refutation of the generally accepted existence of an anterior transverse metatarsal arch. The short first metatarsal, not generally recognized as a cause of foot trouble, is shown to be a common factor and measures are advised for its correction.

In the examination of the foot Dr. Morton stresses the roentgen examination as of prime importance though, as he states, other orthopedists are prone to use this study only to rule out complicating factors such as arthritis, fracture, etc. He also places more importance on the dorsoplantar view than on the lateral view, an idea which would no doubt surprise the average roentgenologist.

Dr. Morton stresses the need for education of the public in foot-care, but also recognizes the fact that education of the public is useless if not preceded by education of the persons who are to provide that care—naturally and preferably, the physician whose training especially qualifies him for this further study.

Any book which will in some measure deliver us from commercial exploitation and quackery in such a field of universal need is surely worthy of study.

E. Walter Hall

Physical Therapeutic Methods in Otolaryngology. By Abraham R. Hollender, M.D., F.A.C.S., Associate in Laryngology, Rhinology, and Otology, University of Illinois College of Medicine; Fellow of the American Academy of Ophthalmology and Otolaryngology. Cloth. Price, $5.00. Pp. 442, with 189 illustrations. St. Louis: The C. V. Mosby Company, 1937.

This excellent book by Dr. Hollender, in collaboration with several well-known specialists, represents a condensed description of the use of physical agents in otolaryngology, with special reference to electrical modalities. There are 442 pages of interesting and instructive matter, with 189 valuable and well-selected illustrations.

The author starts with a section on fundamentals of electrotherapy for the benefit of the large number of otolaryngologists who do not now use electrical measures and for those who use them only half heartedly with little knowledge of why they do so.

The section on diathermy describes in detail the physics which must be understood by those practicing it. Short and ultrashort wave treatments, which are becoming increasingly more popular, are carefully considered.

Part II is devoted to a detailed description of the technique and effects of the accepted physical measures in various types of otolaryngeal conditions. The descriptions are concise and conservative.

Ionization, a subject open to prolonged discussion, pro and con, is well considered.

Part III, "Neoplastic and Miscellaneous Problems" is headed by a chapter by Dr. Chevalier Jackson on endoscopic approach to therapy, with his customary clarity and skill in instruction. The remainder of the section considers malignant and non-malignant neoplasms in detail, finally devoting several pages to definitions which should be of assistance to the otolaryngologist in discussing the methods and modalities used.

The book covers a difficult subject in an able manner and deserves careful consideration by every otolaryngologist who desires to be of the greatest service to his patients by utilizing measures which experience and proper technique have proved to be efficacious.

Frederick M. Law

Die theoretischen Grundlagen und Möglichkeiten der röntgendiagnostischen Weichteiluntersuchung.(*Fortschr. a. d. Geb. d. Röntgenstrahlen*, Ergänzungsband 48.) Von Dr. Adolf Zuppinger, Assistent am Röntgeninstitut der Universität Zürich. Paper. Price. M. 16. Bound. Price, M. 18. Pp. 99, with 46 illustrations. Leipzig: Georg Thieme, 1935.

Good roentgenograms of soft tissue require a very accurate technique since the differences in absorption between the various elements involved are quite small. So far our procedure has been more or less empirical and here is where the investigations of Zuppinger create an entirely new basis. By studying from a physical standpoint the characteristics of film, intensifying screen, spectrum of the radiation used in roentgenography, its qualitative and quantitative changes when passing through tissue, and ways and means to overcome certain shortcomings, he arrives at definite deductions regarding the optimum exposure technique. One important phase of his work concerns the efficacy of contrast media. It appeared that iodine is the least efficient, with thorium topping the list, and silver and bismuth running close seconds. Selenium seems to be the best filter material for roentgenographic purposes. One table in this monograph shows the absorption coefficients of the various tissues as well as of the most common foreign bodies. The special exposure technique for demonstrating varicose veins in the esophagus, the visualization of the hypopharynx including the use of a contrast medium and the roentgenographic demonstration of the epipharynx are described in detail. A number of excellent illustrations are used throughout the text.

This monograph by Zuppinger fills an urgent need in the roentgenologic literature. While only a few points can be mentioned in a brief review, an attempt has been made to give at least some idea of the wealth of accurate information offered by the author. The book is heartily recommended, therefore, to the radiologist who masters scientific German and it is hoped that an English translation will soon be made available.

Ernst A. Pohle

BOOKS RECEIVED

Clinical Roentgenology of the Cardiovascular System: Anatomy, Physiology, Pathology, Experiments and Clinical Applications. By Hugo Roesler, M.D., Associate Professor of Roentgenology and Cardiologist, Department of Medicine, Temple University School of Medicine; Cardiologist, Temple University Hospital; Consulting Cardiologist, Shriner's Hospital for Crippled Children, Philadelphia, Pennsylvania. Cloth. Price, $7.50. Pp. 343, with 199 illustrations. Springfield, Illinois: Charles C Thomas, 1937.

The Digestive Tract: A Radiological Study of its Anatomy, Physiology, and Pathology. By Alfred E. Barclay, O.B.E., M.A., M.D., (Cantab.), D.M.R.E. (Camb.), M.R.C.P., F.A.C.R., Honorary Radiologist to the Nuffield Institute for Medical Research, Oxford; Formerly Lecturer in Medical Radiology, University of Cambridge, Hon. Medical Officer in charge of the X-Ray Department, Manchester Royal Infirmary, and Lecturer in Clinical Radiology, University of Manchester, etc. Second edition. Cloth. Price, $12.00. Pp. 427, with 269 illustrations. Cambridge: At the University Press; New York: The Macmillan Company, 1937.

A Manual of Radiological Diagnosis for Students and General Practitioners. By Ivan C. C. Tchaperoff, M.A., M.D., D.M.R.E.(Camb.), Assistant Radiologist and Radium Registrar, St. Thomas's Hospital, London. With a Foreword by Philip H. Mitchiner, M.D., M.S., F.R.C.S., Surgeon to St. Thomas's Hospital. Cloth. Price, $6.00. Pp. 256, with 286 illustrations. Baltimore: William Wood and Company, 1937.

Handbook of Orthopaedic Surgery. By Alfred Rives Shands, Jr., B.A., M.D., Associate Professor of Surgery in charge of Orthopaedic Surgery, Duke University School of Medicine, and Chief of the Orthopaedic Service, Duke Hospital, Durham, North Carolina, etc. In Collaboration with Richard Beverly Raney, B.A., M.D., Instructor in Orthopaedic Surgery, Duke University School of Medicine. Cloth. Price, $5.00. Pp. 593, with 169 illustrations. St. Louis: The C. V. Mosby Company, 1937.

The Fundamentals of Electrocardiographic Interpretation. By J. Bailey Carter, M.D., Clinical Instructor, Department of Medicine, Rush Medical College, The University of Chicago, Associate Staff, Cook County Hospital, Augustana Hospital, Chicago. With a Foreword by Horatio Burt Williams, M.D., Dalton Professor of Physiology, College of Physicians and Surgeons, Columbia University, New York. Cloth. Price, $4.50. Pp. 326, with 246 illustrations, Springfield, Illinois: Charles C Thomas, 1937.

Die Zuverlässigkeit der Röntgendiagnostik—besonders Hinsichtlich des Wertes der Urographie—und die Prognose bei Nieren- und Harnleitersteinen. (*Acta radiol.*, Suppl. xxxii.) Von Helge B. Wulff. Paper. Price, Swed. cr. 15:—Pp. 301, with 29 illustrations. Stockholm: 1936.

Röntgenologische und pathologisch-anatomische Studien über den Tuberkulösen Primärkomplex. (*Acta radiol.*, Suppl. xxxiii.) Von J. Frimann-Dahl und Georg Waaler. Paper. Price, Swed. cr. 9:—Pp. 60, with 24 illustrations. Oslo: 1936.

Die Hirnkammerformen bei Hirntumoren. (*Fortschr. a. d. Geb. d. Röntgenstrahlen*, Ergänzungsband 52.) Von Dr. Otto Dyes, Dozent für Röntgenheilkunde, Würzburg. Paper, Price M. 16.—; bound, M. 18.—Pp. 79, with 105 illustrations. Leipzig: Georg Thieme, 1937.

Experimentelle Mutationsforschung in der Vererbunglsehre: Beeinflussung der Erbanlagen durch Strahlung und andere Faktoren. (Wissenschaftliche Forschungsberichte, Band 42.) Von N. W. Timoféeff-Ressovsky, Genetische Abteilung des Kaiser-Wilhelm-Instituts für Hirnforschung, Berlin-Buch. Paper, price RM 15.—; bound, RM 16.50. Pp. 181, with 50 illustrations. Dresden und Leipzig: Theodor Steinkopff, 1937.

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., M.S., 105 Rutledge Ave., Charleston, S. C.

A NEW APPLICATOR FOR UNFILTERED RADON

By IRA I. KAPLAN, B.Sc., M.D.
Director, Radiation Therapy Department, Bellevue Hospital
NEW YORK CITY

THE use of glass filtered radon was initiated by Duane in 1914. Marked local destruction occurred, however, around the glass tubules and accordingly more highly filtered applicators were substituted which delivered radiation free from most of the soft beta rays. In the treatment of local superficial lesions, however, it was recognized that circumscribed destruction of the lesion produced good results and this led to the devising of radium applicators that would permit the employment of beta rays. Such applicators were made, for greater convenience, in the form of radium plaques, wherein the radium was applied to a special holder in the form of radium enamel. These plaques, however, were always in a fixed shape and required radium as the base for the active agent. Because radon is an unstable gas which is dissipated

Fig. 1

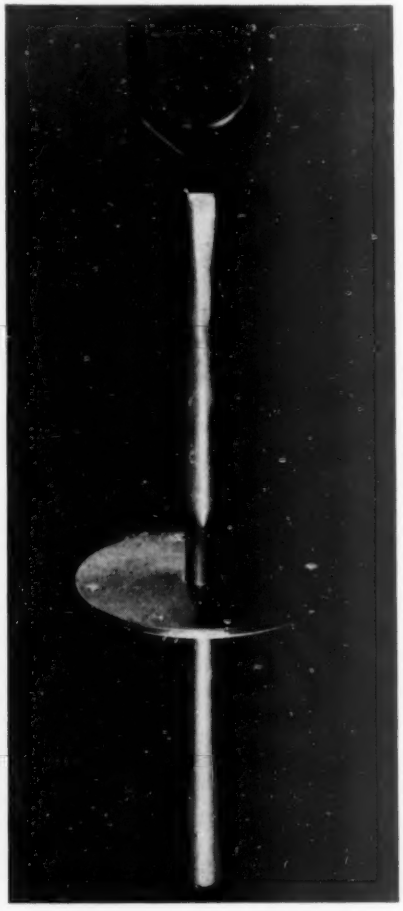


Fig. 2

in about thirty days, and plaques made with radon were not feasible, it became necessary to use glass seeds or tubules.

We have noted in our work good results in the treatment of various types of surface lesions with unfiltered radon tubules. This method has proved particularly effective in cases of small hemangiomata, papillary growths and some nevi. It is also effective in the treatment of keratosis, both benign and malignant, and small basal cell epitheliomata. Unfortunately, however, handling unprotected bare radon tubules is very hazardous both to the physician and to the patient, and accordingly we have devised a special instrument for employing radon tubules effectively and safely. This instrument was constructed after our suggestions by the Physics Laboratory of the Division of Cancer, of which Carl Braestrup is Directing Physicist, and consists of a fiber fork with a light-weight aluminum handle, to which is attached a lead shield to protect the operator's fingers. Between the prongs of the fork is a hollow celluloid cylinder and through this is mounted the radon tubule. This instrument can readily be applied over the area to be treated, the operator holding the charged celluloid cylinder directly over the lesion for the time required to give the desired dose. In some cases the patient himself holds the instrument over the lesion or moves it over the surface to be treated for a specified period, thereby covering all the area needing radium action. The celluloid filtration is negligible and the beta-ray effect is readily secured through it. The time of application varies from one to eight minutes, depending on the type, size and extent of the condition to be treated. A number of cases have been treated with this applicator, with very satisfactory results and entire safety to the operator.

ROENTGENOGRAPHY OF THE CARPAL NAVICULAR BONE

By WILLIAM ROBERT STECHER, M.D.
EASTON, PENNSYLVANIA

MANY fractures of the navicular bone are overlooked in the customary anteroposterior and lateral projections, for there is marked foreshortening of the navicular in the former, and the fracture line accordingly is obscured by the overlapping shadows. Since the vast majority of fractures of the navicular occurs transversely through its mid-portion, it is obvious that it is imperative to align the plane of the fracture line with the beam of roentgen rays, as is shown in Figure 1 *A*. The angle of optimum dorsiflexion of the wrist can be attained by means of a pad, or clenching the fist, which oftentimes suffices to elevate the distal aspect of the navicular into the correct position. Incidentally, this maneuver tends to widen a

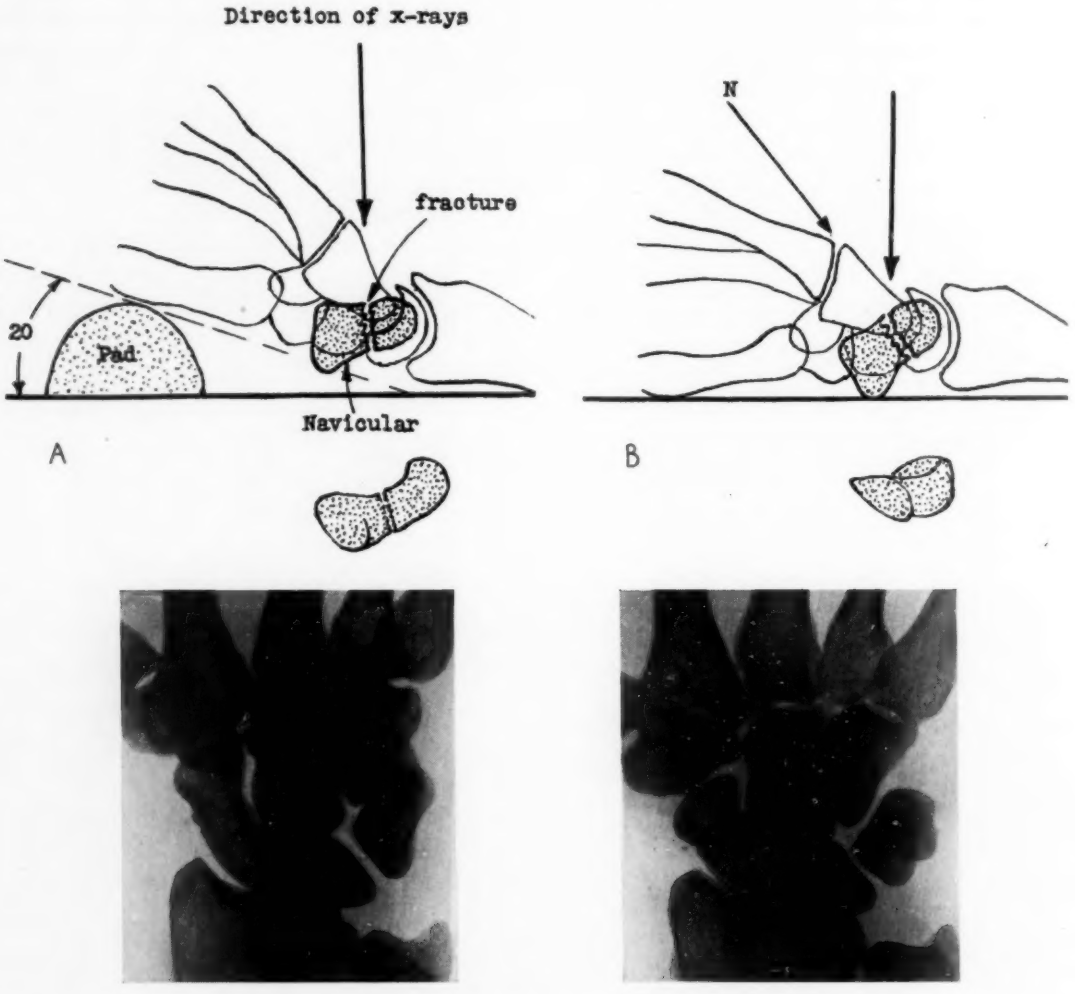


FIG. 1, *A* and *B*. Showing correct position of carpus for detection of fracture of the navicular, also the customary projection.

fracture line, thereby affording a means of detection in excellently coapted fractures which heretofore have not been detected. If this procedure is too painful, one can approximate this effect, though in a less satisfactory manner, by angling the roentgen-ray beam as shown in *N* (Fig. 1 *B*).

A correctly procured lateral projection of the carpus will frequently demonstrate a fractured navicular, by eliminating the magnified distortion resulting from placing the ulnar aspect of the wrist against the film. The proper positioning of the radial aspect of the wrist against the film is more easily done with the forearm flexed. If this is not feasible, then a lateral projection can be obtained by placing an occlusal plane film against the radial aspect of the carpus, with the hand prone, and the roentgen rays directed directly laterad. This is facilitated by placing the wrist upon something such as an empty film box.

It may not be amiss to state that in every case both wrists should be examined. A true os naviculare bipartitum has rarely been shown to be not the result of an antecedent fracture, with pseudarthrosis. Therefore one should never make the mistake of concluding that, although a case of suspicious fracture of the os naviculare, shows no osseous union in six months, the case is therefore an os naviculare bipartitum, for fractures of the navicular rarely heal by osseous union.

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

General

Rahoveanu, G.: Roentgen diagnosis of hydatid cyst 707

Lingeman, L. R.: Infection of soft tissue by gas-producing organisms: early recognition by roentgenogram 707

Geschickter, C. F., and Koehler, H. P.: Ectodermal tumors of the skin 707

ROENTGEN AND RADIUM THERAPY

Feldweg, P.: Irradiation of cancer with soft-filtered radium 708

Altschul, W., and Schiller, V.: Multiple bone tuberculosis 709

Samek, J.: New methods of grenz-ray therapy. 709

Markl, J.: Radium emanation and the organism 710

Hess, P.: The roentgen treatment of absolute glaucoma 710

Sachs, E. Rubinstein, J. E., and Arneson, A. N.: Results of roentgen treatment of a series of one hundred and nineteen gliomas 710

Bardachzi, F.: The roentgen treatment of Basedow's disease 711

Borak, J.: The prospects in roentgen treatment of adenocarcinomata of the breast .. 711

Webster, J. H. D.: The roentgen and radium treatment of operable and borderline cases of cancer of the breast 712

Graham, A.: Cancer of the breast with particular reference to irradiation as a factor in end-results 712

Steiner, G.: A granuloma-like tumor of the thoracic cavity 713

Kleine, H. O.: The influence of syphilis on radiosensitiveness in the radium treatment of cancer of the uterus 714

Granzow, J.: Biology of the irradiated ovary; dermoid in the ovary of a patient irradiated with radium and roentgen rays for carcinoma of the cervix 714

v. Mikulicz-Radecki, F.: Results of elective therapy in the treatment of cancer of the cervix 715

Newell, Q. U., and Crossen, H. S.: Late complications in irradiation treatment of cancer of the cervix 716

Barringer, B. S.: Cystoscopic control by radium of bladder cancer 716

Daland, E. M., Welch, C. E., and Nathanson, I.: One hundred untreated cancers of the rectum 716

Hellebrand, A.: Treatment of arthritis 716

Fried, C.: Roentgen treatment of arthritis ... 717

MISCELLANEOUS

Thoraeus, R.: Some experiences regarding Villard and Witka circuited high-tension generators in roentgen therapy 717

Pfalz, G. J.: The nature and value of weak roentgen irradiation in puerperal mastitis. 718

Kornalik, F.: Biological reactions of incorporated radiant bodies. Cytological changes in the blood cells of warm-blooded animals 718

Hayer, E. Effect of roentgen rays on autolysis and proteolysis of the ligamentum nuchae of cattle 718

Eugster, J., and Hauptmann, W.: Penetrating natural irradiation and cell growth ... 719

Tschechow, W. P., and Kartaschowa, N. N.: Caryological changes in the germinating roots after roentgen irradiation of dry barley seeds 719

Timoféeff-Ressovsky, N. W.: Some experiments on *Drosophila melanogaster* on the relations between the dose and nature of roentgen irradiation and the mutation rate caused by it 720

Arkussky, J. J.: The effect of roentgen irradiation of the spleen on iron metabolism in the animal organism 720

Kahlstorf, A.: The changes in metabolism of surviving tissue after roentgen irradiation 720

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

GENERAL

Rahoveanu, Gh. Röntgendiagnosticul chistului hidactic. (Roentgen diagnosis of hydatid cyst.) *Bul. Soc. de radiol. şi electrol. med. din România*, No. 9, 1934, *3*, 6–9.

The author personally studied 7 cases of hydatid cyst (3 in the liver, 2 in the spleen, 1 in the kidney and 1 in the heart) and from these as well as the data of other cases collected from the literature he establishes the following diagnostic criteria: (1) *Hydatid cyst of the liver.* This appears as a rule in the form of a mild negative shadow because of the greater roentgen permeability of the cyst as compared to the surrounding structures. The shadow is usually rounded and, if located near the superior or posterior aspect of the liver, it may be demonstrated simply by roentgenoscopy or roentgenography, whereas if it is of a central location additional pneumoperitoneum may be necessary to bring out the negative shadow effect to greater advantage. Differential diagnosis includes abscess or neoplasms of the liver and subphrenic abscess. (2) *Hydatid cyst of the lung.* This encounters no diagnostic difficulty and the differentiating criteria are well established. (3) *Hydatid cyst of the kidney.* Ascending as well as descending pyelography is, as a rule, of great diagnostic importance although if a communication of the cyst with the kidney pelvis has been established the appearance may simulate a purulent process or hydronephrosis. (4) *Hydatid cyst of the spleen.* The diagnosis here is based on the same criteria of increased roentgen permeability as is the case in the liver. However, pneumoperitoneum must be added to make the diagnosis more certain.

If the hydatid cyst is localized to other organs such as pancreas, genitalia, muscle, or the skeleton, the diagnosis may become exceedingly difficult.—*T. Leucutia.*

Lingeman, L. R. Infection of soft tissue by gas-producing organisms: early recognition by roentgenogram. *New York State J. Med.*, Feb. 15, 1936, *36*, 259–263.

The procedure for the roentgenological demonstration of gas in the soft tissues is detailed and 5 case reports are presented. Routine films will usually suffice, although care must be taken to avoid overexposure. Gas produced by infection tends to increase in amount and to spread beyond the wound, as contrasted with air introduced by the trauma, which will progressively decrease, unless there be a pleural injury or some types of wounds near joints.—*W. R. Brooksher.*

Geschickter, Charles F., and Koehler, Henry P. Ectodermal tumors of the skin. *Am. J. Cancer*, April, 1935, *23*, 804–836.

In this survey of the various types of tumors of the skin, the authors have attempted to simplify the complicated nomenclature by grouping the various growths either into "epidermal" (squamous cell lesions) or "appendage" tumors (basal cell). They believe this analysis to be rational in that all truly skin tumors arise from the same basal cells; the epidermal tumors are formed from those cells which ordinarily develop into squamous cells and keratin, whereas the appendage tumors form from those cells which would ordinarily form sebaceous glands, sweat glands or hair follicles. Considering the various "grades" of growth activity, such terms as "transitional," "cuboidal" or "mixed-cell" cancer have been applied to those "epidermal" or squamous cell lesions which are growing so fast that keratin (in the form of pearls) are not formed. In like manner other cases of epidermal cancer have been called "grades III or IV undifferentiated carcinoma," or when associated with other tissues such as tonsil, compound terms have been applied such as "lympho-epithelioma." In like manner various "appendage" cell cancers have been named according to histological pictures rather than on the basis of their progenitor cells and tendencies.

A series of 2,100 cases of benign and malignant epidermal and appendage surface tumors were studied. Approximately 1,000 of these were located in the region of the head. Of the rest, about half occurred on the extremities; half on the body proper. Considering only these tumors of external surfaces, the epidermal lesions were about twice as frequent as the

basal. The latter tumors were most frequent about the head, particularly on the face, eyelids and nose, but epidermal lesions were also frequent about the face, particularly in the region of the ear. On the body these types were about equally divided but on the extremities, epidermal lesions predominated.

Benign types of epidermal tumors include the ordinary "corn" or clavus—usually formed in response to mechanical irritation; the ordinary verruca or warts—resulting from an infection by a filterable virus; the squamous cell or "senile" keratoses (acanthoses)—which usually develop as the result of irritation by the sun, wind, hot pitch or paraffin, roentgen or radium radiation, or after repeated arsenic ingestions. These latter lesions are to be respected as being precancerous; the former two types seldom show malignant changes. Lupus vulgaris, lupus erythematosus and the keratoses of Bowen's disease should likewise be respected since they are prone to definite carcinomatous degeneration. Even in the very young these squamous cell changes (and also basal cell) may be found in cases of xeroderma pigmentosum. Some cases of squamous cell carcinoma seem to arise de novo, without a preliminary dermatosis. Depending upon the histological pattern and cellular differentiations these various lesions might be distinguished according to Broders' classifications of grades I, II, III, or IV. Grade III signifies a preponderance of transitional cells but usually a few pearls can be found, but in grade IV pearls are very rare and the cuboidal cell pattern may simulate a basal cell lesion. With high power magnification the spindle cell changes and mitotic activity should identify the case as of squamous cell character. These latter two grades, of course, are the most malignant, even though they may at first appear similar to the more benign basal cell lesions.

Basal cell or "appendage" tumors may be located subepidermally, covered usually by a thin atrophic layer of epidermis, or they may develop superficially. The keratoses, for instance, sometimes called seborrheic keratoses are superficially located. Though they occur usually in later years, as do the senile or squamous cell keratoses, unlike the latter they are found not on a dry skin but rather on an oily skin, and they seldom occur on the backs of the hands. When closely related to hair follicles they may form cysts. More deeply located basal cell tumors include subepidermal basal cell nodules—which histologically show an adenomatous or alveolar arrangement but which cannot be identified with definite glandular or follicular structure; sweat gland adenomas—appearing similar to these lesions but showing histologically a cystic arrangement of coiled acini; sebaceous gland adenomas—an even more cystic lesion, usually multiple and occurring in later years, appearing as small yellowish, slightly translucent, irregular, umbilicated papules, and microscopically showing the structure of sebaceous glands; "turban" tumors—cystic or solid masses ranging in size from that of a pea to a cherry, occurring on the scalp or forehead in numbers from 50 to 500, and microscopically showing relationship to the pilosebaceous apparatus. Sebaceous cysts, pilonidal cysts and tumors of the salivary glands (including abberrant tumors which might be found as far remote from these glands as the dorsum of the hands or wrists) are also examples of subepidermal basal cell or appendage tumors. Basal cell carcinoma (rodent ulcer) may develop from seborrheic keratoses or subepidermal basal cell nodules, or it may arise de novo. These lesions show early fixation of the surrounding skin but the high, hard rolled edge characteristic of epidermal carcinoma is seen late. These lesions erode by extension but they do not metastasize. Other basal cell carcinomas, however, may metastasize, such as adenocystic basal cell cancer; aberrant salivary cancers, or sweat gland cancers. These lesions when occurring on the mucous membranes of the nose, palate, and in the region of the parotid are prone to metastasize, whereas in other characteristic locations, as on the face, metastasis is extremely rare. Where both basal and squamous cell characteristics are found microscopically the prognosis should be based upon the squamous cell activity.

Various ideas as to therapy are also included in this article.—*A. A. de Lorimier.*

ROENTGEN AND RADIUM THERAPY

FELDWEG, P. Krebsbestrahlung mit weichgefiltertem Radium. (Irradiation of cancer with soft-filtered radium.) *Strahlentherapie*, 1934, *49*, 297.

It has been the custom to use hard-filtered radium rays for deep therapy in order to spare the surface. The amounts of radium are correspondingly increased and the irradiation

times lengthened. But in carcinoma of the body of the uterus, it is not possible to prolong the time of irradiation greatly on account of the danger of causing ascending infection from stagnation of secretion and it is not possible to increase the amount or distance of the radium greatly on account of space.

The author therefore attempted to strengthen the action of the rays by soft filtration. The technique of his measurements is described. He found that with 20 mm. distance of the radium preparation aluminum filtration gives an 8 per cent greater yield of radiation than brass filtration. Soft filtration therefore not only increases the surface dose but also intensifies the depth dose.

Four years' clinical experience in 120 cases of carcinoma of the body of the uterus has shown that this strengthening of the radiation by soft filtration is not dangerous. There were no serious injuries, no primary deaths, no peritonitis, no fistulas of bladder or intestine. The only injury observed was a small ulcer of the bladder that healed spontaneously a year and a half after the irradiation without leaving a fistula.—*Audrey G. Morgan.*

Altschul, Walter, and Schiller, Viktor. Multiple Knochentuberkulose. (Multiple bone tuberculosis.) *Strahlentherapie*, 1934, *49*, 451–454.

The authors report a material of 593 cases of surgical tuberculosis, among which there were multiple foci in 52, or almost 9 per cent. They counted only foci in different organs not multiple foci in the same organ, as for instance in several fingers or several vertebrae.

They find it reported in the literature that the majority of cases of multiple tuberculosis are in men and that the right side is more frequently affected. They did not find this confirmed so far as the sides are concerned; both sides were affected in about equal numbers, but they did find a preponderance in men, 37 cases as compared with 15 in women. Apparently the foci develop at about the same time, so they are true multiple foci and not metastases.

In the texts on surgical tuberculosis the prognosis of multiple tuberculosis is reported as very bad. However, this prognosis has been improved since the introduction of light and radiotherapy. But even Starlinger's work of 1933 reports a mortality of 26 per cent in multiple tuberculosis observed for ten years. The author's mortality is only 4 per cent. Though some of these patients may die before the end of the ten year period the mortality will certainly not be nearly so high as Starlinger's.—*Audrey G. Morgan.*

Samek, Julius. Neue Wege der Grenzstrahltherapie. (New methods of grenz-ray therapy.) *Strahlentherapie*, 1934, *49*, 536–540.

Recent investigation has shown that the field of usefulness of grenz-ray therapy can be greatly widened. A patient was recently demonstrated who had been desensitized to eczema by these rays. Quadrangular fields with sides 2 cm. long had been irradiated on the thighs. A total dose of 200 r was given with a half-value layer of 0.03 mm. aluminum; this was given in daily doses of 200 r. Afterward patch tests were made with croton oil and turpentine, some of them placed on irradiated and some on non-irradiated skin. They caused an eczematous reaction of the 2nd and 3rd degree on the non-irradiated skin and no reaction on the irradiated skin.

This fractional method of applying grenz rays has therefore been used to give as large doses as possible without causing disturbing erythema and pigmentation. The method has since been used successfully in 15 cases of eczema.

The value of the method lies not only in the fact that it can be used in the treatment of eczema but that the skin can be desensitized to eczema to a certain extent by its use. The artificial resistance of the skin begins three to four weeks after the end of the irradiation and lasts for eight to ten weeks and then gradually disappears. The duration of the resistance depends on the size of the dose. The lowest dose that brought about desensitization was 1,000 r which desensitized for fourteen days. The optimum dose seems to be about 2,000 r; when 3,000 r was used there was intense pigmentation and the desensitization did not persist for more than ten weeks. By the use of this fractional method the indications for grenz-ray therapy have been extended to acne vulgaris, acne rosacea, pruritus ani and vulvae and lichen ruber planus. It can also be used in those dermatoses which respond readily to grenz rays but in which their use has been considered contraindicated because the dermatoses occur in acute attacks, such as the acute stage of moist eczema, acute attacks of psoriasis and the erythrodermias which result from these

conditions. The fractional doses must be very small in these cases—from 50 to not more than 100 r.—*Audrey G. Morgan.*

Markl, J. Radiumemanation und Organismus. (Radium emanation and the organism.) *Strahlentherapie*, 1934, *49*, 92–117.

The emanation content of the blood was determined before and after baths in water containing radium emanations and an effort made to determine whether the radiant energy is great enough to rise above the threshold of biological action and also to determine the way in which the radium emanation enters the body. On the basis of the emanation content of the blood during and after the bath emanation curves are given showing in cubic centimeters the alpha particles of the emanation and the products of their disintegration and their energy value in ergs; for baths of 1,000–10,000 ME per liter the energy was 10^{-5} ergs per cubic centimeter and second.

These values were compared with the threshold values of biological radioactivity based on Zwaardemaker's experiments on biological radioactivity and it was found that the larger doses used therapeutically or 100 ME per liter and more do reach the threshold of biological activity.

In addition to this direct tissue action of the emanation circulating in the blood, there is also an effect from the contact action of the corpuscular irradiation on the skin, and the penetrating gamma radiation plays its part though its absolute energy contribution is small.

The emanation taken up by the blood does not run parallel with the emanation content of the bath and shows variations in different individuals and in the same individual at different times. The changes in this personal factor are probably due to vegetative nervous influences on the skin, the lowest value for the quotient (maximum concentration of the blood)/(concentration of the water) is 0. 54 per cent, the highest 3.12 per cent, the average 1.7 per cent.

The loss of emanation of the bath water is generally considerably greater when a bath is taken (about 19 per cent) than when the water merely stands exposed to the air (about 10 per cent), but this does not show the amount of emanation taken up by the body because various factors enter into the loss.

The emanation is not taken into the body by inhalation of the small amount of radon above the water but by absorption through the skin, which varies with different persons and at different times.

These investigations are justified by the fact that Lachmann's statistics have shown that the therapeutic activity of the springs does not simply run parallel with their radon content, that many recognized springs are certainly subthreshold and that there is at present no other experimental foundation for determining the mechanism of action of even the strongly radioactive springs.—*Audrey G. Morgan.*

Hess, P. Die Röntgenbehandlung des Glaukoma absolutum. (The roentgen treatment of absolute glaucoma.) *Strahlentherapie*, 1934, *49*, 422–426.

The author has treated 15 cases of absolute glaucoma with roentgen irradiation. An anterior field and a temporal field over the affected eye were irradiated at one treatment with 500 r each with a copper half-value layer of 0.85; fields 4×4 cm. This gave a focal dose of about 800 r distributed not entirely uniformly over the whole eye. A table is given showing the details of the results.

The treatment stopped pain and decreased intraocular tension. Freedom from pain was generally attained in from four to six weeks. The results were completely successful in 9 out of 12 cases of idiopathic glaucoma. One case in which fractional irradiation was used proved refractory. Enucleation had to be performed later on account of ulcer in 2 cases. Among 3 cases of secondary glaucoma enucleation had to be performed later in 2 for cosmetic reasons; one is improved but is still under observation. Secondary glaucomas do not react as well to irradiation as idiopathic glaucomas. If the single dose of 800 r is used, all uncomplicated cases of idiopathic glaucoma can be cured and enucleation avoided.—*Audrey G. Morgan.*

Sachs, Ernest, Rubinstein, Joseph E., and Arneson, A. N. Results of roentgen treatment of a series of one hundred and nineteen gliomas. *Arch. Neurol. & Psychiat.*, March, 1936, *35*, 597–615.

The technique employed in the past eight years is detailed, briefly, 200 kv.(peak), 15 ma., 50 cm. skin-target distance, 1 mm. Cu and 1 mm. Al filters, portals of 12 × 12 cm., the beam centered over the tumor bed and directed straight through to the opposite side.

The average delivered dose was 800–825 r including back-scattering (450 r in air). All tumors were removed as radically as possible, obviating the alarming symptoms of edema which often accompany roentgen therapy alone. Beneficial effect of roentgen therapy was considered to have resulted if there was produced a definite subsidence of symptoms which were still present after tumor extirpation. Illustrative cases of gliomas in the various classifications are presented and the results commented upon. The authors conclude that larger doses of roentgen radiation should be employed and suggest that this can be accomplished by: (1) using multiple portals of entry; (2) employing a prolonged fractional dose method; (3) raising the percentage depth dose either by increasing the skin-target distance or by using heavier filters, or by a combination of both methods, and (4) by devising a safe method of delivering therapy into an open cranial wound. —*W. R. Brooksher.*

Bardachzi, Franz. Die Röntgenbehandlung der Basedowschen Krankheit. (The roentgen treatment of Basedow's disease.) *Strahlentherapie*, 1934, *49*, 618–633.

From a critical study of the literature and his own experience, the author believes that roentgen irradiation should be tried first in practically all cases of Basedow's disease. It is much less dangerous than surgery. If there is not a change for the better in two or three months, operation should be advised. But if the patient refuses to accept operation or is in such condition that it would be dangerous, irradiation should be continued. In very severe cases with a tendency to coma and psychosis, irradiation should not be used until after the general condition has been improved by internal treatment, for example, with diiodotyrosin. In moderately severe cases, roentgen therapy should be begun at once. The decision as to when irradiation shall be stopped and operation performed must be made in each individual case on the basis of the findings, and often taxes the skill of physician and surgeon. The economic factor sometimes has to be taken into consideration, as the patient can be restored to working capacity quicker by operation.

Operation, as a rule, should be performed early in hyperthyroses with signs of compression. If in cases with marked intoxication there is no danger from waiting a while it is justifiable to try irradiation before operation. If the hyperthyroidism has a degenerative constitutional basis, or if there are marked pluriglandular disturbances, as in many cases in the climacteric, operation should not be considered. Internal treatment should be associated with roentgen irradiation of the endocrine glands involved. In toxic adenomata surgery is indicated, but even in this group it may be advisable to overcome severe signs of intoxication by irradiation before proceeding to operation.—*Audrey G. Morgan.*

Borak, J. Die Aussichten der Strahlentherapie bei den Adenokarzinomen der Mamma. (The prospects in roentgen treatment of adenocarcinomata of the breast.) *Strahlentherapie*, 1934, *49*, 263–290.

The author reports 17 cases of carcinoma of the breast irradiated in a period of five years, from 1928 to 1932 inclusive. Histological examination showed that they were adenocarcinomata. In 1928, one patient was treated; she died ten months after the beginning of the irradiation. In 1929, three cases were irradiated; one died eighteen months and one thirty months after the beginning of the irradiation; one patient is still alive at the end of $4\frac{1}{4}$ years. In 1930, two cases were irradiated. The patients died six and sixteen months after the beginning of the irradiation. In 1931, six cases were irradiated. Four of the patients died after 3, 9, 10 and 18 months. Two of them are alive after two and $2\frac{1}{2}$ years. Five cases were irradiated in 1932. One patient died after twelve months. The others have lived 8, 12 and two of them 18 months.

The average interval between the first appearance of tumor and the beginning of irradiation was about two years in these cases. The average life of the patients to death or to their last examination was forty-one months.

The histological changes after irradiation are described in detail and the causes of the failure of roentgen therapy in adenocarcinomata of the breast discussed. The normal mammary gland, like the normal sweat gland, is less sensitive to irradiation than the pavement epithelial epidermis. Neither of these glands can be destroyed by doses of rays that completely destroy the epidermis. Both after these large doses only show slowly progressive degenerative and atrophic changes ending in partial destruction of the gland tissue. Both types of glands can only be destroyed by

amounts of irradiation that cause diffuse connective tissue necrosis. And in both cases total destruction of gland tissue is limited frequently to the areas affected by the necrosis. Adenocarcinoma of the breast behaves in the same way as the normal gland tissue and can only be destroyed by doses of radiation that destroy the surrounding tissue.

This supports the theory that the radiobiological properties of the mother tissue are the decisive elements in the radiosensitiveness of a tumor.—*Audrey G. Morgan.*

Webster, J. H. D. Über die Röntgen und Radiumbehandlung der operablen und Grenzfälle von Brustkrebs. (The roentgen and radium treatment of operable and borderline cases of cancer of the breast.) *Strahlentherapie*, 1934, *49*, 255.

The author's experience covers 41 cases of operative and borderline cases treated with radiotherapy at the Middlesex Hospital in London and 358 operated patients given after-treatment with irradiation. The cases varied greatly clinically and histologically. And different surgeons define operability in different ways. But the average of five year cures in surgery of operable cases varies from 12 to more than 30 per cent. It is generally reported as about 22 per cent. Ewing reports that among 25 patients with palpable axillary glands probably only one can be saved by operation alone.

The author's results with 358 cases irradiated after operation show that the percentage of five year cures can be doubled by postoperative treatment with moderately hard roentgen irradiation. Among the 182 patients observed for five years or longer the percentage of cures was 42 per cent. The percentage of cures in the cases observed for three years was 47 per cent. Three-fourths of these patients came for operation in the second stage and some even in the third stage. A considerable number of the cases were so advanced at the time of operation that they could be given only one or two roentgen treatments, as they then died of metastases.

The author also advocates preoperative roentgen treatment. It is obvious that a method that can cure a considerable percentage of recurrences can also sterilize the field of operation if given two to four weeks before operation, and that this must decrease the percentage of recurrences. He has treated only 10 cases in this way but most of the cases were rendered operable and in some the results were so good that operation was not even necessary. As it is never certain whether an operation has been or will be sufficient, it is a good plan always to combine it with preoperative and postoperative irradiation.

Not only that but he agrees with Ewing's statement eight years ago that in view of the great anatomical and clinical variability of breast cancers, the diagnostic difficulties and the danger of disseminating the tumor by operation, the serious mutilation by radical operation and the frequency of recurrences, it is justifiable to replace operation by radiotherapy in most cases. The 41 operable cases that he has irradiated were most of them not really operable cases because of old age, cachexia, heart and lung diseases or because the cancer itself was very far advanced. Even with this unfavorable material the percentage of five year cures with roentgen rays was 70 per cent and with radium 60 per cent; altogether 66 per cent. These favorable results have been confirmed by other authors.

Among 80 cases of precarcinomatous chronic mastitis there were three year cures in 71 (88.7 per cent).

Intratumoral use of radium did not prove a good method in breast cancer. In a number of cases this treatment was a failure and was quickly followed by local or general metastases. Moreover, if it fails, it renders any further operative or radiotherapy impossible.

Although practicing physicians and surgeons are slow to accept this view he believes the surgical treatment of cancer of the breast should be largely replaced by radiotherapy—*Audrey G. Morgan.*

Graham, Allen. Cancer of the breast with particular reference to irradiation as a factor in end-results. *Pennsylvania M. J.*, March, 1936, *39*, 561–572.

The criteria for the evaluation of end-results in the therapy of carcinoma of the breast are discussed. Four hundred and five cases are analyzed by two groups; (1) those treated by surgery alone, and (2) those who received irradiation in addition to surgical operation. Of 380 patients with cancer of the breast, excluding sarcoma, Paget's disease, sweat-gland cancer and papillary carcinoma, and in whom a five year follow-up was possible, 170 were treated by surgery alone, while 210 were treated by operation and irradiation. The operations were all performed by the same

surgeon. Tabulations of these groups show that of the non-irradiated and irradiated groups, respectively, 94.2 and 96.2 per cent of the deaths which occurred in less than five years were due to cancer; 43.7 and 66.6 per cent of the deaths which occurred after five years were due to cancer; and 82.1 and 90.3 per cent of the total deaths occurring before and after five years were due to cancer.

In the non-irradiated and irradiated groups, respectively, 70 and 56 per cent of the patients who were alive but who were followed for less than five years, were free of cancer; 92.3 and 87.8 per cent of those who were alive more than five years were free of cancer; and 84.8 and 75.8 per cent of those who were alive less than and more than five years were free of cancer.

Clinical evidence of cancer was noted as occurring in less than five years in 42.9 per cent of the non-irradiated and in 55.6 per cent of the irradiated patients who were studied postoperatively; after five years the percentages were 7.9 and 16.6 respectively. In the entire follow-up period, irrespective of duration, clinical evidence of cancer was noted in 50.8 per cent of the non-irradiated and in 66.1 per cent of the irradiated patients.

Of patients followed less than five years, dead or alive, 13.5 per cent of the non-irradiated and 10 per cent of the irradiated were free of cancer. Of those followed more than five years, dead or alive, 35.7 per cent of the non-irradiated and 23.9 per cent of the irradiated were free of cancer; of the total followed less than and more than five years, dead or alive, 42.9 per cent of the non-irradiated and 33.9 per cent of the irradiated were free of cancer.

It is pointed out that there was no general indication of better clinical end-results where irradiation is employed as an adjunct to surgery. Study in successive five year periods elicits the same findings. In the consideration of an apparent variable difference of approximately 10 to 12 per cent in favor of the non-irradiated patients, it was discovered to lie in the relative proportions of favorable and unfavorable cases in the various five-year periods. In a study of patients having malignancies of approximately equal advancement, the clinical end-results were found to be approximately equal and no improvement can be attributed to irradiation. In the author's experience, up to 1930, there is no substantial indication that the roentgen irradiation employed has prevented recurrences, cured recurrences or cured metastases. Roentgen irradiation has unquestioned value as a palliative therapeutic agent.—*W. R. Brooksher.*

Steiner, Georg. Beobachtungen an einem granulomartigen Tumor der Brusthöle. (A granuloma-like tumor of the thoracic cavity.) *Strahlentherapie*, 1934, *49*, 351–356.

In recent years there has been an increase in the number of tumors which show the picture of malignant granuloma; there is no enlargement of the spleen in the majority of cases but the temperature is often subfebrile. These tumors are more frequently localized in the neck and groin than in the lung and mediastinum. Many authors think that the appearance of nodules in the lung means an especially bad prognosis.

The author describes a case in a woman aged forty-eight who came for treatment in January, 1929, on account of emaciation and a certain hyperesthesia but without distinct itching of the skin; there were no lung signs. But on account of dullness over the manubrium she was sent for roentgen examination on the suspicion of mediastinal tumor. The roentgenogram showed a sharply circumscribed, quite dense shadow extending far into the anterior mediastinum and also into Holzknecht's space. As there was no enlargement of spleen or lymph glands, roentgen treatment was given without definite diagnosis: three fields 20×20 cm., two on the thorax and one on the back, 30 cm. focus-skin distance, 55 per cent of an erythema dose, filter 0.5 mm. zinc and 2.0 mm. aluminum, 175 kv. The three fields were irradiated on alternate days within a week. On the twenty-third day after the beginning of the irradiation the leukocytes had fallen from 12,000 to 7,000. Two months after the first series, a second similar series was given and the leukocytes fell to 4,000. Five and a half months after the first series, a third series was given with 60 per cent of a skin erythema dose per field and the leukocytes fell to 2,000. A roentgenogram is given showing the picture eight months after the beginning of the first series and six weeks after the end of the third. Except for a slight protrusion of the middle left arch nothing pathological could be seen in the middle shadow, not even in the oblique diameters. The findings remained unchanged until the end of 1930; there was a considerable gain in weight and the patient felt perfectly well. At

the beginning of 1930, a fourth prophylactic series was given.

The patient was sent back in July, 1931, by a laryngologist on account of catarrhal laryngitis. The middle shadow was normal but the right upper lobe showed a shadow near the base and not far from the midline. In places it was honey-combed, in others denser; there was a second similar shadow in the middle lobe about the size of a walnut. Another series of 55 per cent of a skin erythema dose was given on an anterior field, one posterior and one axillary. Because of severe roentgen sickness the patient refused any further treatment.

She came back in July, 1932, having gained 5 kilograms in weight. The picture was similar to that of the year before except that the upper shadow was somewhat smaller and more sharply circumscribed and there was a clear space in the center of it about 1 cm. in diameter. The slightly decreased air content of the right upper lobe was probably due to atelectasis, not to bronchostenosis. For the first time a supraclavicular gland was demonstrated on the right and was excised. Histological examination showed a chronic lymphadenitis, fibrous in places; in places showing the picture of specific granuloma with plasma cells, eosinophile leukocytes, neutrophile giant cells similar to Sternberg's cells and proliferations of reticulo-endothelial cells. The pictures suggested a lymphogranulomatosis in places of the so-called blastomatous type.

The patient now complained for the first time of coughing. A single weak distant irradiation caused still more intense sickness than before. Up to the end of October, 1932, the findings were unchanged.

It is possible that the lung tumor was due to a migration from the hilus, but at the time of the appearance of the change in the lungs the mediastinum was free of changes that could be demonstrated roentgenologically. The author is inclined to think the lung focus developed independently of the mediastinal tumor. This is important as metastases must be irradiated much more intensely. This case proves that the prognosis is not particularly bad in lung nodules.

The dose must be individualized in granulomatosis. The problem is different from that in true malignant tumors; the resistance of the surrounding tissue probably plays a much more important part. It is particularly important to use the smallest effective doses in granuloma. It is probably better to fractionate the doses than to use even as much as 60 per cent of an erythema dose at once. In this case the irradiation of one field per day with 55–60 per cent of an erythema dose proved effective, as there has been no recurrence in the mediastinum.—*Audrey G. Morgan.*

Kleine, H. O. Zur Frage der Beeinflussung der Strahlenempfindlichkeit durch Lues bei Radiumbehandlung von Gebärmutterkrebsen. (The influence of syphilis on radiosensitiveness in the radium treatment of cancer of the uterus.) *Strahlentherapie*, 1934, *49*, 415–421.

The author reports 20 patients with carinoma of the cervix and 2 with carcinoma of the body of the uterus treated with radium. All of them had syphilis. He found that the syphilis did not affect the number of permanent cures but that the patients with syphilis showed a higher percentage of injuries from the irradiation than the non-syphilitic ones. There were 2 cases of vesicovaginal and rectovaginal fistula, 1 ulcer of the bladder and 2 cases of severe injury of the rectal mucous membrane in this group of cases. During this period there was only one injury from irradiation observed among the much larger number of non-syphilitic patients.

Of course in comparing with other clinics the details of technique must be taken into consideration. He gave doses of 4,500 to 6,000 mg-hr. with a filtration of 1 mm. brass and 0.2 mm. silver. For further details of his technique he refers to a previous article. He believes that injuries from irradiation can be lessened by the use of hard filtration and fractional application. The fact remains, however, that in his material with the same technique and the same observation time there was a higher percentage of injuries in syphilitic cases.—*Audrey G. Morgan.*

Granzow, Joachim. Zur Biologie des Strahlenovars: Dermoid in Ovarium einer wegen Kollumkarzinoms mit Radium und Röntgen Bestrahlten. (Biology of the irradiated ovary; dermoid in the ovary of a patient irradiated with radium and roentgen rays for carcinoma of the cervix.) *Strahlentherapie*, 1934, *49*, 694–702.

A woman of forty-one who was still menstruating regularly came for treatment for a carcinoma of the cervix, stage III. She was given combined roentgen and radium treatment. She promptly became amenorrheic and twenty-seven months after the close of the radiotherapy

was normal clinically and the adnexa were normal on palpation. After five more months, that is, two years and eight months after the irradiation, a tumor of the ovary the size of a fist was demonstrated; operation showed that it was a typical benign ovarian cyst. The ovary on the other side showed the typical picture of roentgen castration and the uterus the picture of irradiation climacteric and healed cancer.

Each ovary in this case had been given a combined radium and roentgen dose of 45 per cent + 112 per cent of an erythema dose, that is $4\frac{1}{2}$ times the calculated castration dose which is 35 per cent of an erythema dose.

A number of cases in which tumor developed in an ovary after roentgen castration have been described in the literature. Five of them are briefly reviewed. None of them were dermoids, however, and in none of the cases had such a large dose of irradiation been given, but only the ordinary myoma dose.

There are two theories in regard to the histogenesis of ovarian dermoids: one that they originate from ovum cells and the other that they originate from blastomeres, or cell complexes from the earliest stage of embryonic development which have somehow been retained at the site of the later development of the tumor. In this case, the ovum cell theory is hardly tenable as no ovum cell could have survived such heavy irradiation. The blastomere theory is tenable only on the assumption that the blastomere cells were slumbering or in a resting stage at the time of the irradiation and were later awakened to renewed mitosis in some unexplained way. This theory is, however, more plausible than the first one.

This case shows that there is no roentgen castration in the strict sense of the word. Roentgen amenorrhea does not prove at all that the ovary is excluded anatomically or biologically. There could be no more conclusive proof that the vitality of at least certain cells in the ovary is preserved than the development in it of a new growth after irradiation. All such cases should be reported for the sake of clearing up the genesis of these tumors.—*Audrey G. Morgan.*

v. Mikulicz-Radecki, F. Erfolge der elektiven Therapie bei der Behandlung des Gebärmutterhalskrebses. (Results of elective therapy in the treatment of cancer of the cervix.) *Strahlentherapie*, 1934, *49*, 407–414.

By elective therapy the author means that in operable cases surgery is used and in inoperable cases irradiation. Also that in many cases surgery is followed by irradiation. He thinks that for comparative purposes only the absolute figures for cure should be used; that is, only the percentages of cures as related to the total number of cases treated in the hospital, not simply the percentage of selected groups of cases, as, for example, the operable cases for surgical statistics.

He says that elective therapy saves more patients than surgical treatment alone or irradiation alone and as evidence of this contention submits the statistics from 11 hospitals in Germany, Austria and Switzerland, from 1919 to 1926. This is the most recent material that permits of a five-year observation time. He gives tables showing the results. With a total material of 5,455 cases there were 1,339 five year cures, which is 24.5 per cent absolute cure. Pankow's statistics for operation and for irradiation show an absolute cure of only 17 per cent. Therefore elective therapy saves 7.5 per cent more of the total material, or in Germany at the present time elective therapy saves 40 per cent more patients than surgery alone or irradiation alone.

Another table is given showing the material of Bumm and Stoeckel for 1910–1927. In this material of 3,385 cases 933 were permanently cured (five year cures). This is 27.5 per cent, and in Stoeckel's material alone, which includes more than 1,000 cases, the number of cases permanently cured was 30.5 per cent. This means that elective therapy is superior to radiotherapy alone by 50 per cent. It also means that it is now possible by properly selected treatment to save one-third of the patients with carcinoma of the cervix, which is a great advance in the fight against carcinoma.

This improvement was brought about by radical operation on about a third of the material. The author believes the superiority of radical operation is due to the fact that the parametria are removed at once from the body. The operative mortality has been 10–12 per cent but it has been lowered recently by the use of vaginal radical operation; recent statistics show only 5.7 per cent mortality with this method. There is therefore no longer any reason to reject operation on account of high operative mortality. Simple total extirpation of the uterus is not enough. The operation must be radical if good results are to be obtained.—*Audrey G. Morgan.*

Newell, Quitman U., and Crossen, Harry S. Late complications in irradiation treatment of cancer of the cervix. *Surg., Gynec. & Obst.*, April, 1935, *60*, 763–768.

The effective treatment of cancer of the cervix uteri necessarily carries considerable risk to the patient. The risk is less with irradiation than with operation, but irradiation carries definite dangers. The serious responsibility and difficult problems in the use of radium in this situation are not generally appreciated. If the dose is too small, the distant cancer cells survive and the patient dies of recurrence. If the dosage is pushed to the point of causing devitalization of the outlying cancer cells, there is danger of irradiation injury of the rectum and bladder and the ureters.

In the intensive radiation treatment of 371 patients with carcinoma of the cervix, most of them advanced, the authors encountered the following late complications:

Rectal stricture: 5 cases, mostly mild and all yielding satisfactorily to dilatation treatment.

Bladder ulceration: 4 cases, all responding to irrigations and instillations, and only 1 requiring fulguration to stop bleeding.

Sloughing of the skin: 1 case of extensive sloughing with subsequent healing. There was also 1 case of subcutaneous infiltration (first degree) which seemed stationary, and 1 case of subcutaneous infiltration with superficial vascular change (second degree), which was definitely progressive.—*J. H. Vastine.*

Barringer, Benjamin S. Cystoscopic control by radium of bladder cancer. *Am. J. Surg.*, April, 1935, *28*, 47–54.

Barringer reports 36 patients with carcinomas of the bladder which have been controlled for periods of from one to twenty years by the cystoscopic application of radon. Either the small papillary tumor or the small flat indurated ulcerating type is suitable for this form of therapy. The technique is fully described.—*W. R. Brooksher.*

Daland, Ernest M., Welch, Claude E., and Nathanson, Ira. One hundred untreated cancers of the rectum. *New England J. Med.*, March 5, 1936, *214*, 451–455.

The analysis of 100 untreated cases of rectal cancer shows that they live just as long with no treatment as they will if only a colostomy is performed, the median duration in this series being fourteen months. However, colostomy contributes greatly to their comfort during this period. Roentgen therapy as an additional measure aids in the relief of pain. The operative mortality for radical resection is sufficiently low to warrant surgery when there is a probability that the growth can be removed.—*W. R. Brooksher.*

Hellebrand, Alois. Zur Arthritisbehandlung. (Treatment of arthritis.) *Strahlentherapie*, 1934, *49*, 676–677.

As a gynecologist, the author calls attention to the great importance of arthritis in gynecology. This is natural as the ovary exercises a great influence on the development and course of this disease through its internal secretion and the vegetative nervous system. Arthritis frequently develops after removal of the ovaries and in premature climacteric. And chronic arthritis is very frequent after the beginning of the climacteric. The relation between the ovary and Heberden's nodes is generally known. There are severe inflammations of the joints in puerperal sepsis and in other gynecological infections, gonorrhea for example. The course of acute joint rheumatism is particularly severe during pregnancy and frequently ends in ankylosis. Noorden in 11 cases of acute joint rheumatism in pregnancy saw 9 ankyloses in spite of all treatment.

The gynecologist takes on a heavy responsibility in giving consent to marriage or pregnancy during or after acute joint rheumatism. This is particularly true when the roentgen picture is not decisive, as in the beginning stages of osteoarthritis deformans. The maximum frequency of osteoarthritis deformans is in the climacteric. Most authorities classify osteoarthritis deformans as a disease of the climacteric.

Treatment of arthritis deformans was of little value before the introduction of roentgen irradiation. Generally good results are attained even with small doses. The author remarks, however, that in the very beginning of violent cases irradiation is not very effective and better results are obtained by puncture, followed by washing out the joint and installation of rivanol.

Practitioners do not know as much as they should about the roentgen treatment of arthritis. This may be because the beginning stages of osteoarthritis deformans are not easy to recognize and may be mistakenly diagnosed.

Diagnoses of neuralgia and rheumatoid disease are often made. The correct diagnosis is not made and the proper treatment given until after the roentgen picture becomes characteristic and that is often quite late.—*Audrey G. Morgan.*

Fried, Carl. Die Röntgentherapie der Arthritis. (Roentgen treatment of arthritis.) *Strahlentherapie*, 1934, *49*, 634–675.

The author reviews the history of the roentgen treatment of arthritis beginning with Sokolow who in 1897 first treated 4 cases of joint rheumatism in children with irradiation with good results. In 1905 Moser reported good results from roentgen irradiation in different forms of joint disease, including gout and rheumatism. The roentgen treatment of gonorrheal arthritis was first described by Dominici and Gy in 1907.

He gives tables showing the results from the literature and his own results in the treatment of the different forms of arthritis, infectious, atrophic and hypertrophic.

The most marked effects of roentgen treatment are control of pain and decrease of swelling. These effects are brought about in all forms of arthritis. The control of pain is particularly marked in gonorrheal arthritis in which the pain is unendurable and necessitates immobilization of the joints. Splinting of the joints often causes ankylosis. Roentgen treatment makes it possible to remove the splints sooner and prevent ankylosis. Pain is controlled more quickly in acute than in subacute and chronic cases and radiotherapy should be begun in as early a stage of the disease as possible. In acute and subacute cases with fever the temperature is also reduced to normal.

Typical cases of the different forms of arthritis are described and illustrated. In treatment all authors use hard filters and moderate to high tensions. The doses vary from 10 to 100 per cent of a skin erythema dose. The majority use from 20 to 30 per cent of an erythema dose. The intervals between irradiations vary from three days to three weeks. The author himself gives a beginning dose of 140–150 r for the knee and hip joints (25 per cent of a skin erythema dose), for the shoulder 120 r and for the ankle, wrist and finger joints 90–120 r, always from both sides. For the small joints and shoulder the dose normally remains the same. For the knee and hip the second irradiation is reduced to the dose for the next smaller joint (120 r). If improvement occurs, the dose remains the same thereafter. It is not decreased but as improvement continues the intervals are lengthened, from two weeks to three, four and six weeks. If improvement does not begin after the second irradiation or does not continue at any stage in the treatment the dose is increased to the next higher stage, generally by 40 r; the maximum dosage which is only rarely used is 300 r. The other conditions are as usual: 160–180 kv., 4 ma., 0.5 mm. copper and 1 mm, aluminum filter, 30 and 40 cm. focus-skin distance, depending on the depth of the joint.

Local irradiation is always used except in those forms of arthropathy due to endocrine disturbance, in which the affected glands may be irradiated. In 2 cases of tabetic arthropathy Käding had good results from irradiating the lumbar marrow. Langer irradiated the spinal ganglia successfully, and in this connection the author discusses the different theories in regard to the mechanism of action of the rays in arthritis. He concludes that irradiation is not to be used indiscriminately in all cases of arthritis, except in gonorrheal cases in which it should always be used as early as possible. It is also of great value in severe cases of chronic-rheumatic and deforming arthritis and its value in these cases should be better known to physicians so that sufferers from these severe diseases might profit from its use.—*Audrey G. Morgan.*

MISCELLANEOUS

Thoraeus, R. Some experiences regarding Villard and Witka circuited high-tension generators in roentgen therapy. *Acta radiol.*, 1935, *16*, 621–628.

The author reports a comparison of the different high tension generators used at the present time in roentgen therapy—the Greinacher, Villard and Witka systems. He discusses the voltage curves produced and gives the capacity of the ordinary tubes for producing roentgen rays as related to voltages of the same maximum value and rays of equivalent quality. The influence and capacity of high tension cables are also discussed and illustrated by direct measurements. The destruction of the focal surface and the consequent decreased power of irradiation found in all tubes with a hot anode on the use of Villard or Witka generators were followed up by direct measurements for a long time. On the basis of practical

experience the author discusses the length of usefulness and the working capacity of the different roentgen tubes.—*Audrey G. Morgan.*

PFALZ, G. J. Über Wesen und Wert der Röntgenschwachbestrahlung bei puerperaler Mastitis. (The nature and value of weak roentgen irradiation in puerperal mastitis.) *Strahlentherapie*, 1934, *49*, 357–406.

Experiments in the irradiation of artificially produced mastitis in guinea pigs are described. The mastitis was induced by giving injections of staphylococci that had been rendered pathogenic for animals by repeated passages through guinea pigs. After these experiments weak roentgen irradiation was applied in 41 cases of mastitis in human subjects.

The author concludes that weak roentgen irradiation acts in puerperal mastitis as a nonspecific immunization with a general increase of the functional activity of the cells. The practical value of this radio-immune reaction lies in the fact that it results in an intense inhibition of all inflammatory reactions and complications.

This justifies the systematic use of the method for all forms of puerperal mastitis, and particularly for the abortive treatment of infiltrative early mastitis. For the irradiation of the animals, a cylindrical glass tube with walls 3 mm. thick and a lumen of 4 cm. diameter was attached to the Holfelder protective cannon of the SRV apparatus; size of the field 12.6 sq. cm. A dose of 320 R was used, with 180 kv. tension, 4 ma., 36.5 cm. focus-skin distance and 0.8 mm. copper filtration. For the human cases tube fields of 10×15 cm. were used with 40 cm. focus-skin distance, with a single dose of 50–60 R. The other conditions were the same as for the animal experiments.

The weak roentgen irradiation proved effective in beginning infiltrative forms as well as in chronic, renitent and recurrent pus foci; it lowered temperature, controlled pain and brought about absorption of inflammatory infiltrations or drying up of chronic exudates. Advanced extensive infiltrations and foci that were already fluctuating showed more rapid liquefaction and sharp localization of the abscesses. No injurious by-effects were observed, particularly no disturbances of lactation caused by the irradiation.

For determining the immunobiological action of the irradiation the bactericidal index was determined by Wright's method. It was found that the immune reaction was brought about by an action of the rays on the blood, not on the injected bacteria. The white blood picture showed an increase of all the signs of the neutrophile stage of struggle in infiltrative mastitis and of the lymphocytic curative phase in mammary abscesses.

Weak roentgen irradiation is the treatment of choice in puerperal mastitis. Early use of the irradiation is important.—*Audrey G. Morgan.*

KORNALIK, FRANZ. Biologische Reaktionen inkorporierter Strahler. Zytologische Veränderungen an poikilothermen Blutzellen. (Biological reactions of incorporated radiant bodies. Cytological changes in the blood cells of warm-blooded animals.) *Strahlentherapie*, 1934, *49*, 707–711.

In an article last year (*Strahlentherapie*, 1933, *47*, 746) the author showed that the blood cells of the lower vertebrates are very sensitive indicators for the biological action of radiant substances. Under certain experimental conditions, a broadly graduated scale of radiosensitiveness of the different forms of blood cells could be determined using only a few millicuries of radium.

In this article, similar experiments on the blood cells of warm-blooded animals are described. They show that the rays have the most marked effect on the least differentiated forms of cells and the effect decreases as the cells become more highly differentiated. The changes are described in detail and illustrated with photomicrographs. They include vacuolization and in some cases stricture of the nuclei. The author thinks it may be possible to utilize these findings therapeutically.—*Audrey G. Morgan.*

HAYER, E. Einwirkung der Röntgenstrahlen auf Autolyse und Proteolyse des Nackenbandes vom Rind. (Effect of roentgen rays on autolysis and proteolysis of the ligamentum nuchae of cattle.) *Strahlentherapie*, 1934, *49*, 678–693.

The effect of roentgen rays on the autolysis and proteolysis of various animal tissues has been tested by different investigators. The results were found to differ, depending on whether the tissues were in their normal position in the animal body and therefore affected by total irradiation or were isolated and only the cells of the particular organ or tissue were acted on by the irradiation. In the former case, autolysis and proteolysis were hastened and in the latter retarded.

The author repeated these experiments, using the ligamentum nuchae of cattle as the test object. This tissue was selected because the elastic tissue of this ligament seems to be particularly sensitive to the action of the rays. Bits of the isolated ligament were subjected to physical, histological and optical methods of examination and were also digested with different ferments to test proteolysis. The details of the experiments are described.

It was found in experiments in stretching and tearing the ligament that autolysis was delayed by roentgen irradiation, the optimum effect being attained with a dosage of about 600 r.

The results of macroscopic and microscopic examination ran parallel with these, as the decreased staining reactions of the nuclei and collagenous connective tissue caused by autolysis were delayed by the irradiation.

The optical characteristics of the collagenous tissue were not affected either by autolysis or irradiation. Experiments in digesting the ligament tissue with pepsin and trypsin did not show any difference in the digestibility of the tissue with and without irradiation.—*Audrey G. Morgan.*

Eugster, J., and Hauptmann, W. Durchdringende Umgebungstrahlung und Zellwachstum. (Penetrating natural irradiation and cell growth.) *Strahlentherapie*, 1934, *49*, 223–237.

The authors discuss the effect of the so-called natural irradiation on cell growth. Natural irradiation includes the irradiation from the earth and from the air and from radioactive substances contained in the air. It differs at different altitudes and under different climatic conditions. In order to test the effect of this irradiation and find out how biological processes would be affected in a medium practically free of irradiation, they tested the growth of seeds and of bacteria at three different altitudes, 2,340 meters above sea level, 1,400 meters above sea level and 570 meters above sea level. The details of the experiments are described and tables given showing the results.

They found that the germination and growth of the seeds and the growth of the bacteria was hastened as the total intensity of the natural irradiation decreased. Microscopic examination of bacteria cultivated under different intensities of irradiation did not show any morphological differences due to the differences in natural irradiation. If these observations are confirmed in more highly organized cell tissues, it would seem that natural irradiation is an important factor in the regulation of normal cell growth.

This would be of special interest in the cancer question. The world-wide increase of cancer might be explained as due to the disappearance in recent times of a controlling factor which acted in the same manner as gamma rays upon animal tissues.—*Audrey G. Morgan.*

Tschechow, W. P., and Kartaschowa, N. N. Karyologische Veränderungen der Keimwurzeln nach Röntgenbestrahlung von trockenen Gerstensamen. (Caryological changes in the germinating roots after roentgen irradiation of dry barley seeds.) *Strahlentherapie*, 1934, *49*, 238–250.

The authors studied the effect of roentgen irradiation on germination of dry barley seeds. They found that roentgen irradiation may have a fatal effect on dry seeds, not only by killing the seeds after they have germinated but by decreasing the number of seeds that germinate to one-fourth to one-half the number that germinate in control experiments.

They also wanted to determine whether roentgen rays can act on dry seeds in such a way as to cause caryological changes and therefore produce chromosomal mutations. They used small doses which should have a stimulating effect and larger ones which should have an inhibiting action. The details of the experiments are described. They found that all the doses had an inhibiting action on growth but that the greatest effect was brought about not by large but by small doses. Curves are given showing the times of exposure and dosages that produced the greatest inhibition of growth.

They also found that the irradiation caused changes in the process of caryokinesis. It was found that the doses of irradiation that had the greatest inhibiting effect on growth also caused the greatest changes in the mitotic cells. With short exposure the metaphases contained normal chromosomes, with longer exposure the chromosomes were changed. Details of the changes and the dosages and exposure times which produced them are given.

The roentgen irradiation of dry seeds therefore causes caryological changes in the roots germinating from them. These changes may be explained in two ways: they may be caused either by immediate action of the rays on the chromosomes while the nuclei are still in the

stage of division, or by action of the rays on the resting nucleus and its surroundings. These experiments on dry seeds show that an immediate action of the rays on the chromosomes is not necessary to the production of these caryological changes.—*Audrey G. Morgan.*

Timoféeff-Ressovsky, N. W. Einige Versuche an Drosophila melanogaster über die Beziehungen zwischen Dosis und Art der Röntgenbestrahlung und der dadurch ausgelösten Mutationsrate. (Some experiments on *Drosophila melanogaster* on the relations between the dose and nature of roentgen irradiation and the mutation rate caused by it.) *Strahlentherapie*, 1934, *49*, 463–478.

Experiments on *Drosophila melanogaster* are discussed. The details of the technique are described and tables and curves given showing the results. It was found that the mutation rates caused by roentgen irradiation are directly proportional to dosage. The proportion between lethal and visible mutations was not changed by increasing the dose. Dilution or fractionating of the dose did not have any effect on the mutation rate. The mutation rate was not dependent on the hardness of the radiation. There was no difference in irradiation at high and low temperatures.—*Audrey G. Morgan.*

Arkussky, J. J. Über die Wirkung der Röntgenbestrahlung der Milz auf den Eisenstoffwechsel im tierischen Organismus. (The effect of roentgen irradiation of the spleen on iron metabolism in the animal organism.) *Strahlentherapie*, 1934, *49*, 455–462.

The author reports experiments on the irradiation of the spleens of rabbits in order to determine the effect on iron metabolism. Tables are given showing the details of the results. He found that irradiation of the spleen with very large doses or even total removal of the spleen caused decreased and not increased iron metabolism. The decrease was slight. The liver as well as the spleen is involved in iron metabolism and when the spleen is injured or removed the liver takes over its iron-metabolizing function.—*Audrey G. Morgan.*

Kahlstorf, A. Die Veränderungen des Stoffwechsels überlebender Gewebe nach Röntgenbestrahlung. (The changes in metabolism of surviving tissue after roentgen irradiation.) *Strahlentherapie*, 1934, *49*, 427–437.

The author made experiments to determine the effect of radiotherapy on the metabolism of living tissue. He used the liver and testicle of white rats. The rest of the bodies of the animals were protected and the organs irradiated with a dose of 600 r. The details of the preparation of the tissues and the metabolism determinations are described and tables given showing the results.

The metabolism of the liver and testicle tissues of the rats injured by a single roentgen irradiation showed decreased oxygen consumption and increased aerobic and anaerobic glycolysis. This shows a certain resemblance to the type of metabolism of malignant tissue. But there is one important difference. The tissue metabolism of a malignant tumor is characterized not only by increased glycolysis but also by the fact that glycolysis is only slightly inhibited by oxygen. But in this irradiated tissue the inhibiting action of oxygen on glycolysis was practically normal. Therefore, tissue injured by roentgen irradiation does not show the most essential characteristic of malignant tissue; that is, lack of dependence of increased fermentation metabolism on respiration.

The decreased respiration and increased glycolysis in the irradiated tissue are not constant enough in amount so that conclusions can be drawn from them in regard to the comparative action of single and fractional dosage.—*Audrey G. Morgan.*